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URBAN SUNRISE

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13. ABSTRACT ***(Maximum 200 Words)***

This report describes the research performed to explore the potential to enhance military urban operations, planning and execution, by providing new civil intelligence preparation-analysis and Effects Based Operations (EBO) planning capabilities to the urban warfighters and occupying civil adminstrations. The objective is to provide a comprehensive capability for construction of urban civil intelligence for dynamic effects-based operations analysts to coordinate administrative, information, and military security operations for greatest effects. A “three-domain” urban model was developed to model human organizational behavior (cognitive domain), information paths and structures (information domain), and the physical infrastructure of the urban area of interest (physical domain). This effort was a “seedling” effort to conduct the basic research and develop the theory. A follow-on effort by the Army will develop the static description and dynamic simulation of the three urban domains, providing visualization and explanation facilities to allow analysts and planners to explore the consequences of effects based administrative, security and information operations.

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General Dynamics- Dr. Russ Vane (Principal Investigator), Woody Spring (Colonel USA, Ret.), Ed Waltz, Tom Tulenko, Mike Schenaker, Jeff White (consultant)

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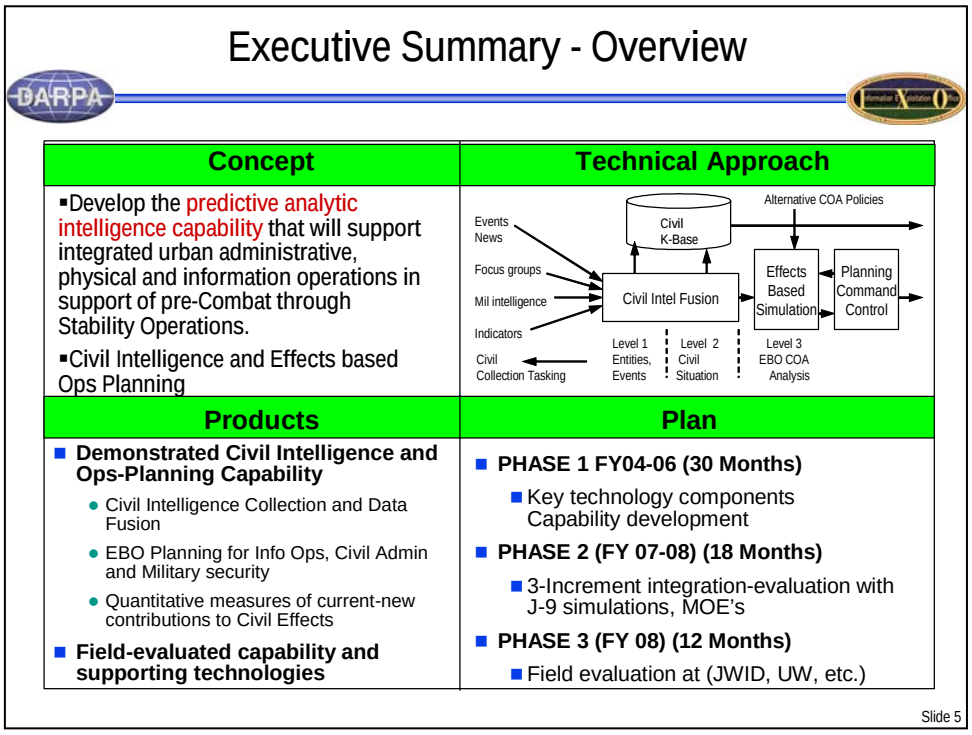
URBAN SUNRISE

Synthetic Urban Networks and Relationships Intelligence and Simulation Environment

Executive Summary

The URBAN SUNRISE seedling has explored the potential to enhance military urban operations planning and execution, by providing new civil intelligence preparation-analysis and effects based operations (EBO) planning capabilities to the urban warfighters and occupying civil administrations. The capability will provide a comprehensive capability for construction of urban civil intelligence and will allow dynamic effects-based operations analyses to coordinate administrative, information, and military security operations for greatest effects.

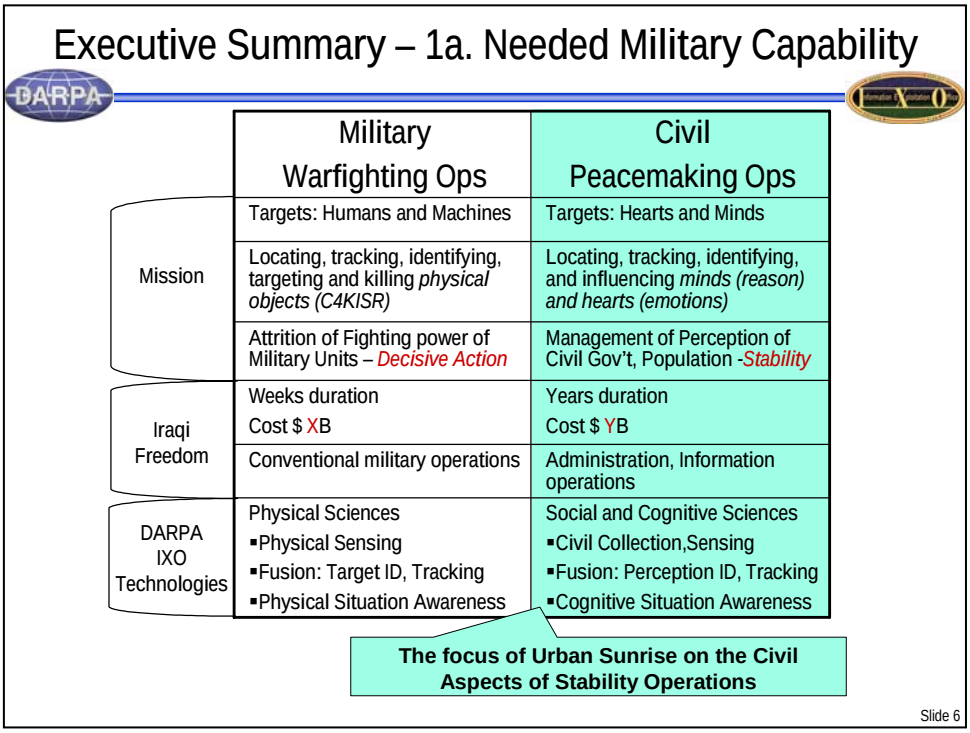


Overview The recommended DARPA program will develop the predictive analytic capability to represent, model and evaluate effects of operations on urban civil populations and opposition organizations (e.g. belligerents, terrorists, etc.) The approach follows a "three-domain" urban model that acknowledges the need to model human organizational behavior (cognitive domain), information paths and structures (information domain) and the physical infrastructure of the urban area of interest (physical domain). The URBAN SUNRISE capability will allow static description and dynamic simulation of the three urban domains providing visualization and explanation facilities to allow analysts and planners to explore the

consequences of effects based administrative, security and information operations. The URBAN SUNRISE program will deliver the following products:

- A demonstrated Civil Intelligence and Ops-Planning Capability that includes Civil Intelligence Collection, Civil Data Fusion, and an integrated EBO Planning for Info Ops, Civil Admin and Military security. The capability will provide quantitative measures of intelligence *and* operations effectiveness to allow comparison of new contributions to current capabilities.
- A field-evaluated capability and supporting technologies

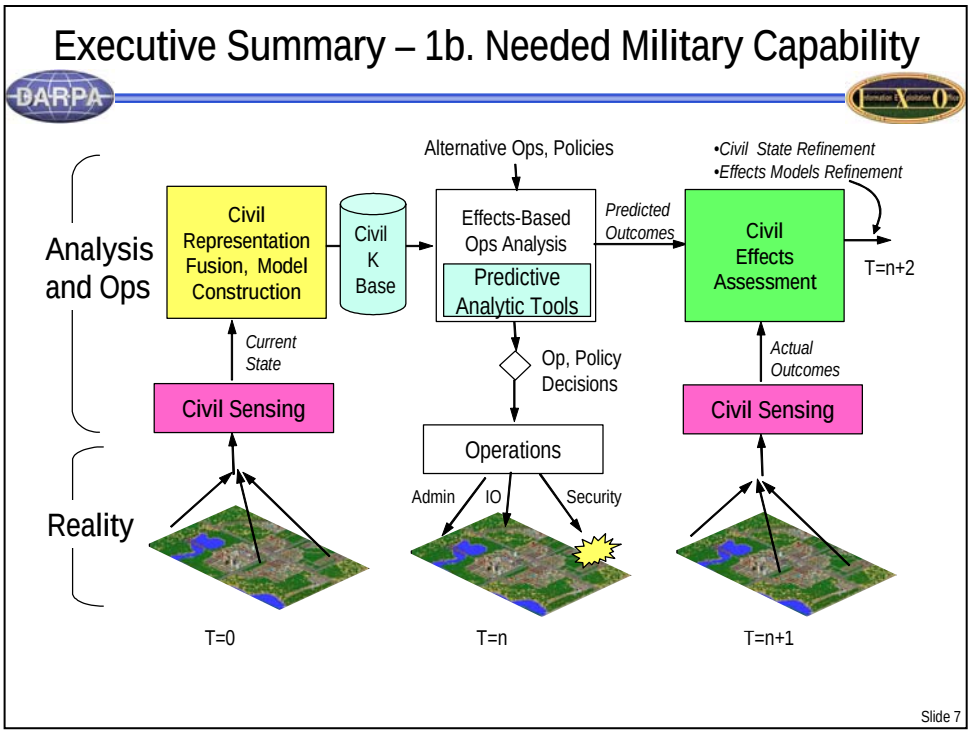
Needed Military Capability - The focus of URBAN SUNRISE is on civil peacemaking operations, in contrast with military warfignting operations (below).



While traditional military warfighting focuses on military personnel and machinery, the focus of URBAN SURISE is on civil populations, their "hearts and minds". The focus of this program is on management of civil population perceptions, rather than the attrition of military fighting power. The required DARPA research focus will be in the areas of the cognitive and social sciences – modeling human behavior and the effects of civil affairs and military security operations to manage perceptions and wills.

URBAN SUNRISE will provide **Foreign Civil Intelligence**, defined as that *intelligence derived from all sources regarding the social, political and economic aspects of governments & civil populations, their demographics, structures, capabilities, organizations, people, and events.* (This definition has been based on consideration of several alternatives to describe civilian social, political, and economic information: 1) Civil Considerations—the political, social, economic, and cultural factors of and AOR (Army FM 3-07 para. 2.7), 2) Civil Considerations– the influence of manmade infrastructure, civilian institutions, and attitudes & activities of the civilian leaders, populations, and organizations within an AOR on the conduct of

military operations (Army FM-06), and 3) "Cultural Intelligence" defined in USMC Urban GIRH; and often cited by Gen. Zinni.)



The functional operations needed to implement URBAN SUNRISE (above) include several phases of activity:

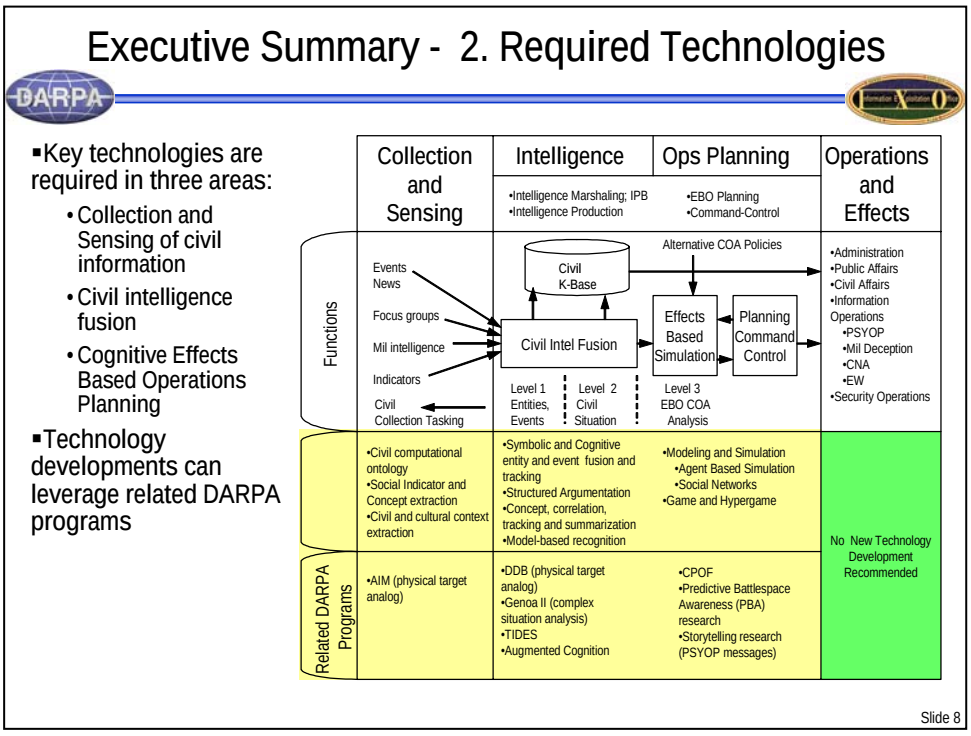
1. Foreign Civil Collection – Civil information is collected from multiple sources
2. Foreign Civil Intelligence Representation and Fusion – Civil information must be used to represent actor-organizations, the flows of influencing information and constraining urban structures. The civil data fusion process must correlate and combine civil sources (e.g. text reports, media, polls, etc.) and new technical sensing sources into parameters that update simulations models of civil populations, their governments, and the information and physical infrastructure environment within which they live and act.
3. Civil Knowledgebase – The accumulated information forms a dynamic knowledgebase of civil intelligence for 1) direct query and analysis by intelligence analysts, and 2) translation into model data for EBO simulation.
4. Effects Based Ops Analysis – Urban simulation tools allow predictive and exploratory analysis of the effects of integrated operations on the mix of civil populations and belligerent organizations.
5. Operations – Integrated operations are carried out on the basis of more comprehensive understanding of the *potential* interactions of actors in the complex environment.
6. Civil effects Assessment – URBAN SUNRISE must include the capability to assess predicted and actual effects, and to refine effects models on the basis of those assessments.

Required Technologies – The URBAN SUNRISE program will require the development and integration of numerous technologies in three major areas:

1. Technologies to collect, extract and representation civil data from existing and new technical sources;
   - Civil behavior technical sensors
   - Civil computational ontology (DAML, RKF)
   - Civil automatic indicator recognition (Civil-ATR)
   - Social Indicator and Concept extraction from unstructured sources
   - Civil context extraction

2. Technologies for automated and semi-automated civil intelligence knowledgebase creation; creation of civil data inputs for EBO models;
   - Symbolic and Cognitive entity and event fusion and tracking
   - Structured Argumentation
   - Concept, correlation, tracking and summarization
   - Model-based recognition

3. Technologies to simulate non-military operations, civil populations, and effects; Analysis of effects in complex and highly uncertain simulations
   - Human behavior Representation
   - Modeling and Simulation
     - Agent Based Simulation
     - Social Network Analysis
   - Game and Hypergame
   - Complexity of effects-space analysis



Measuring Impact – The URBAN SUNRISE program will measure the *impact* of the contribution of the new capability at three levels: 1) Civil Population *Performance Measures* will quantify how increased civil intelligence will impact the timeliness, accuracy, depth of civil situation understanding. They will also quantify how increased civil cooperation leads to increased intelligence breadth, depth. 2) Operations Impact *Effectiveness Measures* will quantify how enhanced Civil Situation Awareness will lead to improved commander's decision making and improved degrees of civil influence, and improved contributions to Administrative, Information, and Military Op Effectiveness (outcomes), 3) finally *Military Mission Utility Measures* quantify the effects on civil stability (security, productivity, health, growth, trust, etc.).

The impact of URBAN SUNRISE must be measured r*elative to*:

1. Current Practice – Experienced judgment, tacit knowledge
2. Alternative Military Missions – Pre-combat, combat, Stability and Support Ops
3. Alternative Operations – Administrative, Information (IO), Military security

The table (below) summarizes examples of quantitative metrics that can assess the contribution of URBAN SUNRISE capabilities on urban military operations at all three levels cited above.

Executive Summary – 3. Measuring Impact

- Measure the *Impact* of Contribution of New Capability:
  - Civil Population Performance Measures:
    - Increased Civil Intelligence ? Timeliness, Accuracy, Depth
    - Increased civil cooperation ? Intelligence breadth, depth
  - Operations Impact Effectiveness Measures:
    - Civil Situation Awareness ? Commander's Decision Making degree of civil influence
    - Civil Situation Awareness ? Contribution to Administrative, Information, and Military Op Effectiveness (outcome) Measures
  - Military Mission Utility Measures:
    - Civil Stability (Security, Civility, Productivity, Health, Growth, Trust)
- Measure Impact *Relative to*:
  - 1. Current Practice – Experienced judgment, tacit knowledge
  - 2. Alternative Military Missions – Pre-combat, combat, Pre-stability, Stability and Support Ops
  - 3. Alternative Operations – Administrative, Information (IO), Military security

Civil Intelligence Impact Measures

Category	Description	Example Measures
Civil Intelligence Performance Measures	Increased Civil Intelligence	Civil Intel Volume, Timeliness, Accuracy, Depth
		EBO planning predictive accuracy
		EBO options coverage
Operations Impact Effectiveness Measures (Op'l MOE's)	Measures of Situation Awareness contribution to warning, assessment and operational planning and decision making	PSYOP influence (outcome) measures
		Civil Admin policy (outcome) measures
		IO (outcome) Measures
		Security operations (outcome) measures
		Civil cooperation; Intel participation
Military Mission Utility Measures (Mission MOE's)	High-level Measures of Overall Civil Stability in an AOR or Urban Area	Civil Security (e.g. crime rates)
		Civil Trust and Responsiveness to Civil Affairs (demonstrations)
		Social Health (e.g. refugees, mortality rates)
		Civil Infrastructure and Environmental Quality
		Economic Productivity and Growth (utility availability)
		Political Stability (policy and governance change rate)
		Resistance (Attacks)

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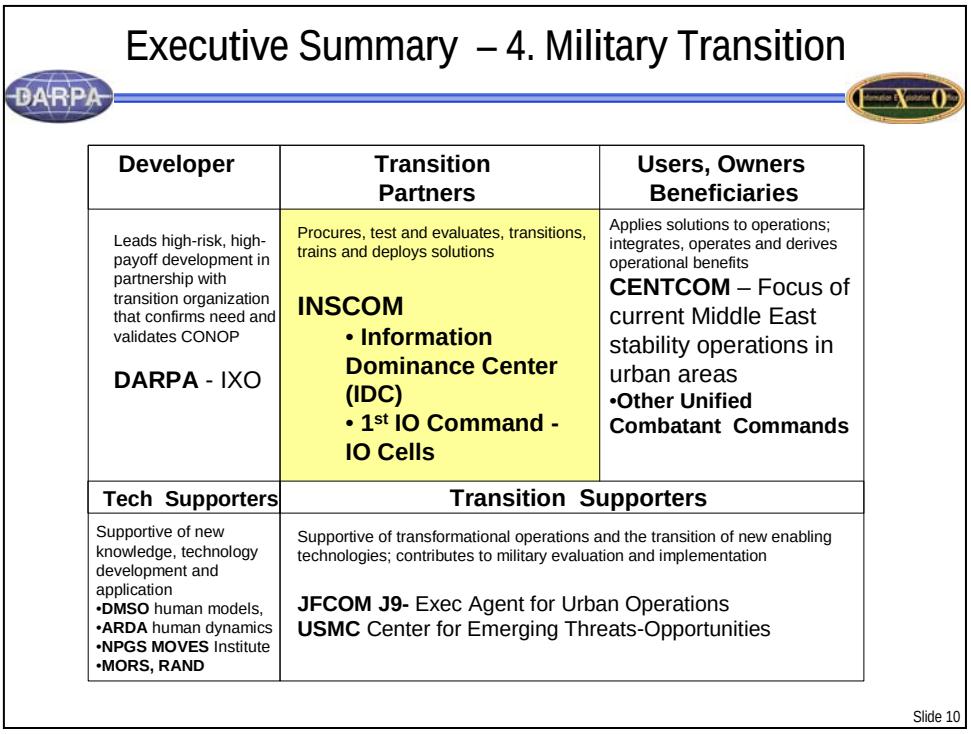
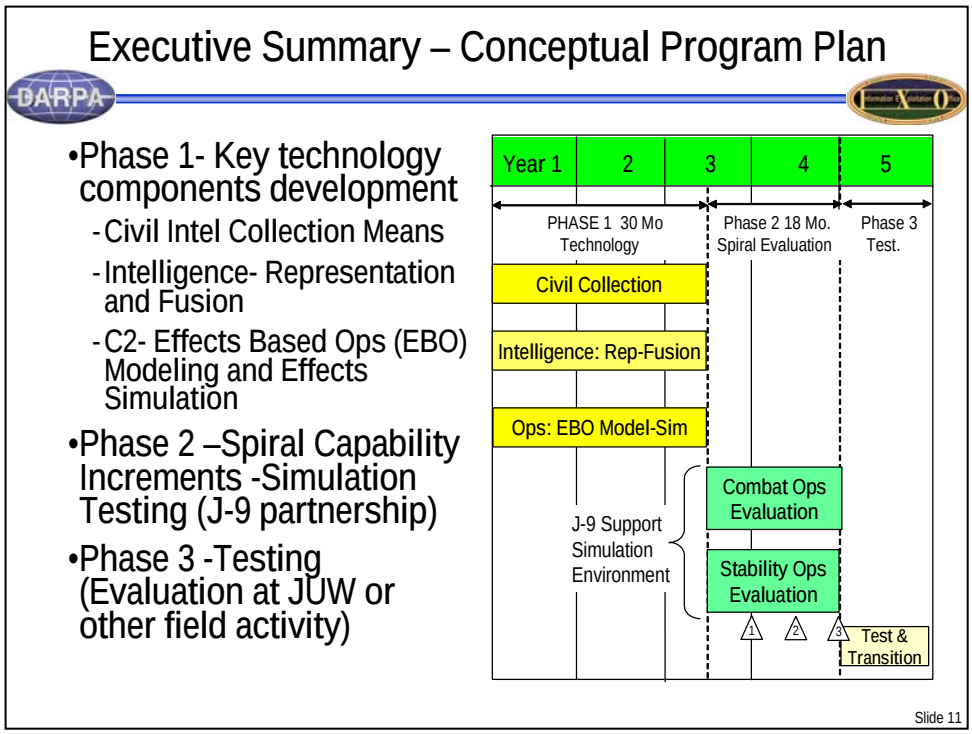
Military Transition - The transition parties (chart, below) include interested technology and operations supporters, partners, and ultimate users, owners and

beneficiaries. The key parties for the new URBAN SUNRISE capability identified in the study are:

- Transition Partner – INSCOM is the logical partner, because of the Army's primary responsibility for on-the-ground urban warfigning, control and occupation. Additionally INSCOM maintains the first IO Command, and operates the Information Dominance Center (IDC) at Ft, Belviore that develops and operationally applies capabilities such as URBAN SUNRISE.
- Transition Supporter- JFCOM J-9 has responsibility for urban warfare experimentation, and runs the annual Joint Urban Warfighter (JUW) exercises, making it the logical partner for experimentation.
- Technology Supporters – There exist a number of organizations that are supportive of these technology developments (especially effects based human dynamics simulation) for application to the complexity of urban and asymmetric warfare, including: Defense Modeling and Simulation Office (DMSO), Advanced Research and Development Activity (ARDA), MORS, and the RAND Corp.



Conceptual Program Plan – A conceptual URBAN SUNRISE program is structure in three phases (below) over a five year program. The first phase develops the key technology components, before integrating them to evaluate end-to-end capabilities in phase 2. Phase 3 will conduct filed experimentation to evaluate operational utility.



Phase 1: During phase 1,The Integrating contractor will assign MOEs to individual contractors for their technology solutions. The contractors, in turn, will be required to submit MOPs for their products as well as functional test plans for the technology they are developing. The integration contractor will write the overall test plan for this and subsequent phases, which will include working with J9 and transition partners. Products will be integrated into the program baseline on 6-month centers, and will undergo integration testing and functional testing as appropriate. The integration contractor will develop an end of phase test plan that will lead into the J9 evaluation and prove readiness for the spiral phase of user evaluation.

Phase 2: is the spiral development phase. The initial phase will evaluate the program software as developed and will directly support the program objectives established with JFCOM J9. The first spiral will include contractor training and extensive or as needed contractor support. It is anticipated that the first JFCOM J9 evaluation will be a Red Team type exercise with Civil play and intelligence derived from real world (probably Iraq) data. The second spiral will again be at the call of the J9, and will include contractor training and minimal, but as required support for the operators. The third phase will again include contractor training from mature training manuals, but the exercise will involve contractor support for trouble shooting only.

Phase 3: is the Test and Evaluation phase with the user community and the transition partner. During phase 1, and iterated in conjunction with the user community, a final test plan will be developed by the integration contractor. Normally, the user community increases user involvement as a function of system maturity which is proven through a series of evaluations. The user community will have seen the J9 tests, and may opt for a CPX (command post exercise) followed by a limited field evaluation, and finally a real world evaluation. The intention is to have prototype transition systems be used with the evolved CONOP. The critical metric will

be whether the service will adopt the system and make it part of their war fighting baseline.

Summary – As evidenced in current operations in the Balkans, Afghanistan and Iraq, there exists a critical need for civil intelligence collection, fusion and civil effects-based ops modeling and simulation to support urban combat and stability operations. This need has been articulated by the Joint Staff, the Defense Science Board and the military services as cited in this report. URBAN SUNRISE will provide civil behavior representation, fusion and predictive EBO is as high-risk, high-payoff venture, suitable for DARPA investment. INSCOM and JFCOM are suitable transition partners, eager to receive and apply the capability.

1. MILITARY NEED

The Defense Science Board observed as early as 1996 that, "cities are the most likely battlefield of the 21st century." The U.S. Intelligence Community projects that by 2015 more than half of the world's population will dwell in urban areas; more than 400 million will reside in mega-cities containing more than 10 million people.[1] The U.S. military is preparing for increased combat in complex foreign urban areas, as the growing population in the third world is continually moving toward urban population concentrations, where the U.S. may be required to confront terrorist centers, rogue dictators or dug-in military units.[2] Current doctrine for Military Operations on Urbanized Terrain (MOUT) emphasizes the importance of understanding the unique urban "terrain." This terrain includes more than the complex network of streets, buildings, and subsurface facilities. The urban terrain includes:

- Infrastructure including utilities and public works,
- Diverse populations organized in "neighborhoods" characterized by culture (beliefs, goals, aspirations, cognitive-emotive styles) and physical location
- Complex flows of information between the civil population groups, and competing military forces.

The complexity of urban areas poses both *analytic* and *operational* challenges that are addressed by the Urban Sunrise capabilities. The following subsections describe the issues with constructing useful models of the urban physical terrain, information and cognitive environments, the Urban Sunrise technical approach, and relevant related technology developments.

This study was conducted in response to IXO's interest in "*new and novel techniques both to permit improved intelligence preparation of the battle space and improved predictive battle space awareness. Topics of particular interest include terrain amplification and interpretation tools, behavior analysis tools, … effects based engagement planning and assessment tools, and others*" (BAA 03-03). The study has evaluated urban Intelligence Preparation of the Battlespace (IPB) and Effects Based Operations (EBO) capabilities that integrate geospatial and cultural intelligence models to enable predictive urban battlespace analysis of *the complete geophysical, information, and cognitive structure* of the urban environment. .This study addresses the need for greater cultural awareness of the urban battlespace – including the intangible information and cognitive infrastructures that describe the flows of information across the urban terrain, and the perceptions and beliefs of civil, government and military populations. The study has specifically addressed the shortfalls in current IPB doctrine noted by a recent RAND study: "Population analysis, which includes both demographic analysis and cultural intelligence, should come to the analytic foreground."[3]

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[1] Global Trends 2015: A Dialogue about the Future with Nongovernment Experts, U.S. National Intelligence Council, December 2000, Section 5, "Population Trends".

[2] Doctrine for Joint Urban Operations, Joint Pub 3-06, Joint Chiefs of Staff, 16 September 2002.

[3] Medby, Jamison J., and Glenn, Russell W., "Street Smart: Intelligence Preparation of the Battlefield for Urban Operations", RAND, MR-1287-A, 2002, P. 134. This proposal addresses the major needs identified in the RAND study.

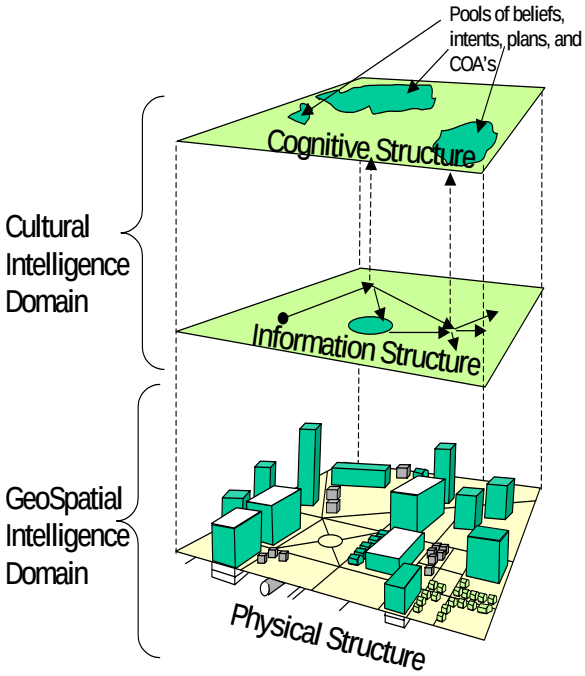
The desired Urban Sunrise capability will provide the following functions:

- Collect and integrate foreign civil intelligence data (social, political, and economic) into an IPB knowledge base of the geospatial, information and cognitive states of the terrain, communications, media, and urban populations, respectively.

- Performs behavioral simulations of the effects of physical and information operations.

- Provides an assessment of urban civil population groups, and describes the relationships between them and their perceptions.

- Enables the predictive analysis of causes and effects using agent-based simulation to create a landscape of feasible outcomes and effects of military operations (both physical and information ops).



1.1. Civil Intelligence Needs in Combat and Stability Operations

This study has conceived a new type of Intelligence Preparation of the Battlespace (IPB) and Effects Based Operations (EBO) analysis capability for intelligence analysts and military operations planners that will:

- Integrate models of the terrain, communication, and cognitive states of the urban population and government decision-makers.
- Performs behavioral simulations of the effects of physical and information operations in urban areas of operations.
- Provide perceptual assessment of urban population groups, visualizes relationships between groups and their perceptions.
- Enable the predictive analysis of effects using agent-based simulation to create a landscape of feasible consequences and outcomes of military operations.

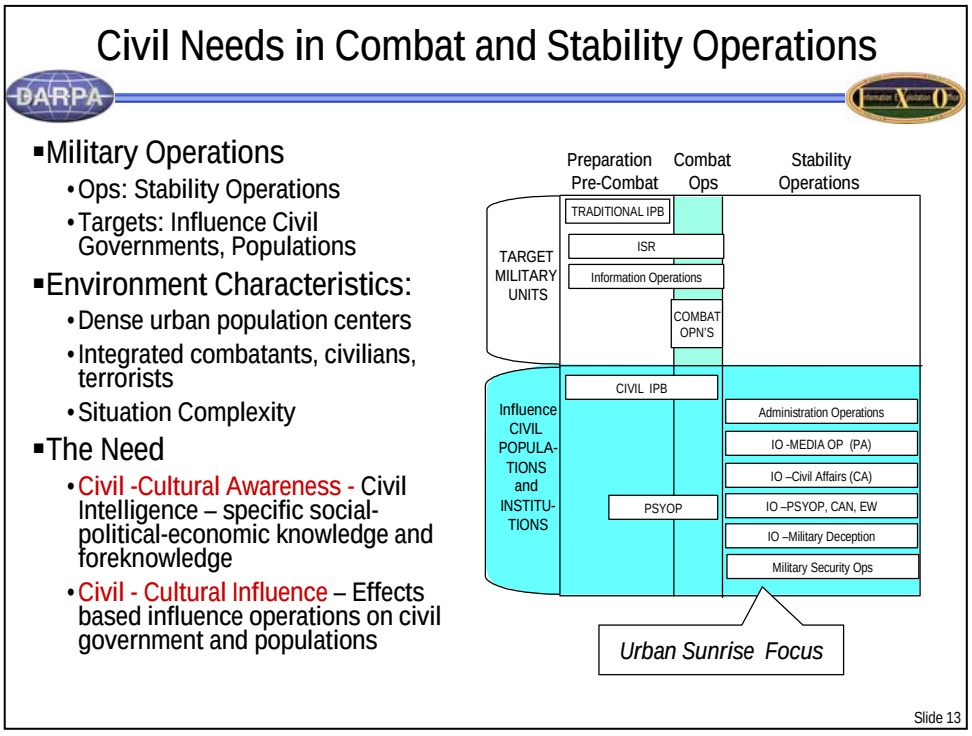
These capabilities will revolutionize urban operations planning and execution, providing military commanders with the following impacts and benefits:

- Modeling Benefit - The capability will provide a comprehensive template for construction of an urban IPB knowledge base that includes both geophysical and cultural intelligence factors.
- Simulation Benefit – The capability will allow the simulation of dynamic effects-based operations to analyze and plan coordinated physical and

information operations for greatest impact. Information Operations (IO) cells will be able to simulate the effects of integrated public affairs and military operations (physical, security, deception, PSYOP, and electronic operations) to conduct anticipated "three block wars" in urban terrain.[4]

- Understanding Benefit – This capability will allow analysts to explore emergent behaviors of urban complex adaptive systems of people, communications, and the effects of information and physical actions to reduce the potential for strategic surprise.

The capability will be integrated into military intelligence, operations and operations cells. For IO cells, the capability will be integrated in accordance with Joint Pub 3-13; specifically to support the "IO Planning Coordination, Integration and Deconfliction" operations. [5]



The military operations supported include pre-combat through Stability Operations, and the target focus is the influence of foreign civil governments, and civil populations. The environment characteristics include dense urban population centers where there are integrated combatants, civilians, and terrorist populations. This tightly integrated set of interacting actors provides a high degree of situation complexity.

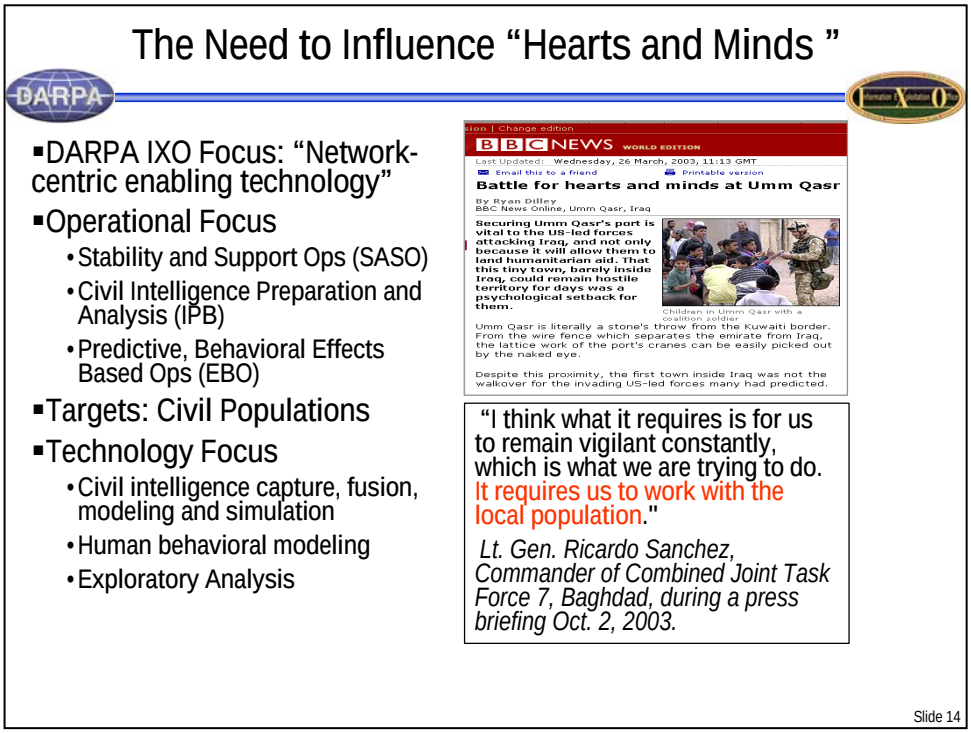
[4] The "three block war" refers to the need for simultaneous peacekeeping, humanitarian assistance and lethal battles to be conducted on different blocks in the urban terrain. The concept was introduced by the former commandant of the Marine Corps, Gen. Charles C. Krulak, "The Three Block War: Fighting in Urban Areas," National Press Club, Vital Speeches of the Day, 15 December 1997.

[5] Joint Pub 3-13 "Joint Doctrine for Information Operations", 9 October 1998, see page V-4.

The need, therefore, is twofold:

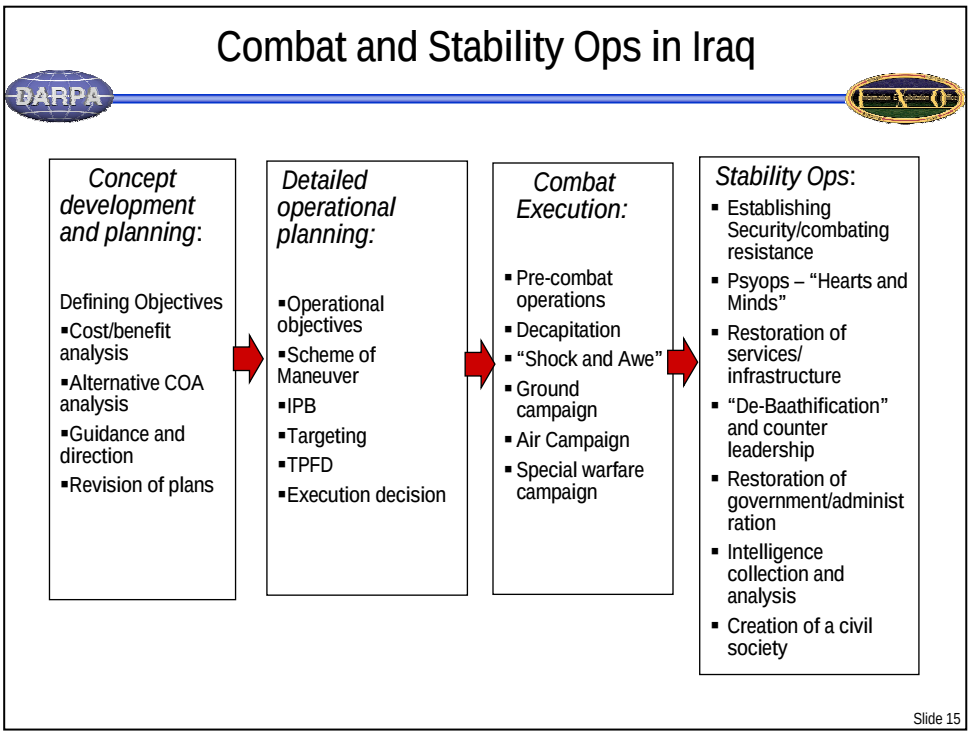
- Civil -Cultural Awareness, or Civil Intelligence – specific social-political-economic knowledge and foreknowledge
- Civil - Cultural Influence – Effects based influence operations on foreign civil governments and civil populations with embedded opposition elements

In common terminology, there exists a need to support those operations that influence the "hearts and minds" of civil populations to support the overall military mission.



The DARPA IXO focus includes the development of "Network-centric enabling technologies" and Urban Sunrise is consistent with this focus. The operational focus is on Pre-combat through Stability and Support Ops (SASO), implementing capabilities to support both Civil Intelligence Preparation and Analysis (IPB) and predictive, Behavioral Effects Based Ops (EBO). The targets of these operations are foreign civil populations. The technology focus is on:

•Civil intelligence capture, fusion, modeling and simulation
•Human behavioral modeling
•Exploratory Analysis



Consider the current needs for Urban Sunrise capabilities in the combat through stability operations in Iraq. Combat and stability operations are intimately linked, and are part of a continuum extending from initial concepts (should we go to war, why, and to what end), to an eventual transition to operations supporting a new political reality (who rules and under what law). In each phase there are distinct types of operations and activities that will occur, and actions in each phase will effect the situation in following phases. The URBAN SUNRISE approach provides knowledge base tools and predictive analysis across the continuum of combat and stability operations, permitting an integrated and coherent approach to all phases.

- Concept Development and Planning – The actions taken in this phase will largely determine the broad conduct of the campaign or operation, establish the desired objectives for the operation as a whole, and shape the broad outlines of the outcome of the operations. It made an enormous difference that operation Iraqi Freedom was ultimately about regime change vice simply enforcing UN resolutions.
- Detailed Operational Planning – In this phase the way the operation will be conducted is determined in detail. Broad concepts, such as "regime change" are converted into detailed objectives, targets, maneuver schemes and force flows. In this stage the final execution decision is made.
- Execution – The execution phase may begin with pre-combat operations, such as the insertion of Special Warfare units and intelligence collection assets. Depending on the plan, results and timing, this phase will shift emphasize between kinetic and non-kinetic operations and actions. Outcomes here will largely determine the detailed situation as the transition to stability operations begins.
- Stability Operations – Some level of combat ("pockets of resistance") may continue into this phase; but the emphasis shifts to psychological operations,

civil affairs actions, restoring services, and establishing a civil administration. Intelligence plays a critical role in achieving an understanding of the situation and projecting future developments.

Scope of Stability Operations

Area of Interest	Example	Characteristics (illustrative)
Nation State	Iraq	Complex geography; Large, diverse population; political, ethnic religious divisions; disrupted political, security, social, economic, and infrastructure systems; attitudes to coalition range from resistance to collaboration
Region	Sunni Triangle	Several small cities and many towns/ villages with broad open areas; largely homogenous culture (with diverse pockets); tribal overlay; affinity overlay; diverse economic activity; moderate infrastructure; marked hostility toward occupation, active resistance elements present
Rural	Nasiriyah region	City center, small towns, villages; agricultural areas/terrain; tribal overlay; family overlay, affinity overlay, limited economic activity, personal influence of religious leaders and mosques, limited cooperation with coalition elements, emerging resistance potential
Urban Centers	Baghdad	Urban terrain; large and diverse population; center of political, social, academic, and economic life; family, religious, affinity overlays; elaborate infrastructure; numerous sub-compartments (neighborhoods, blocks, districts); active resistance elements; mixed cooperation with coalition
Urban Environs	Greater Mosul	Urban center, satellite towns; large and ethnically diverse population; numerous sub-compartments; elaborate infrastructure; active resistance elements, mixed cooperation with coalition

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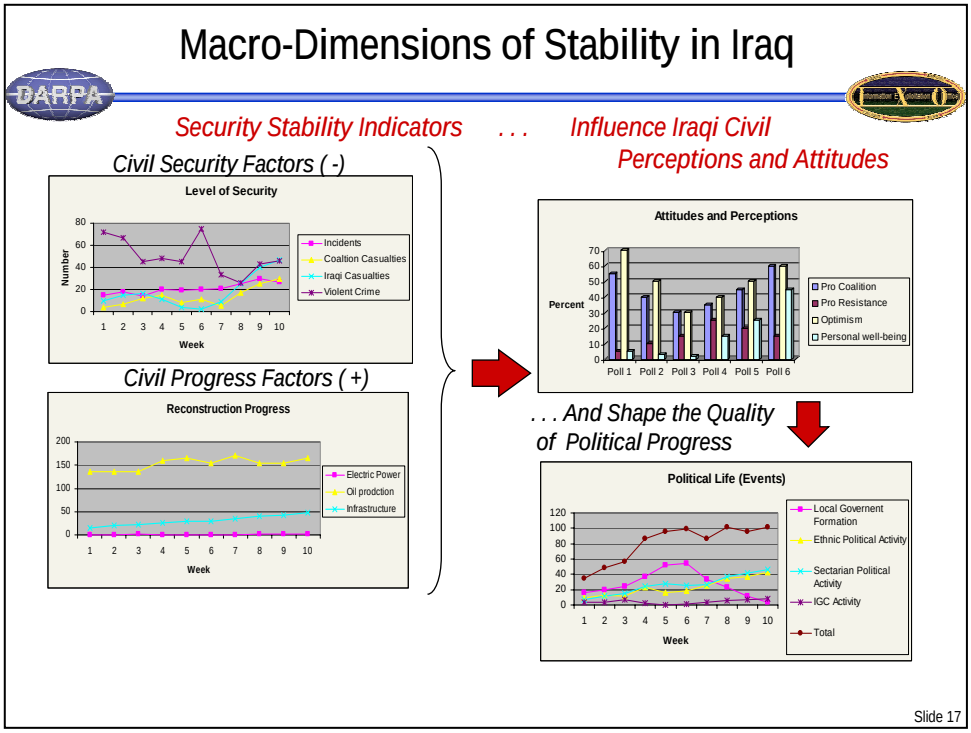
While urban areas represent a specific case for stability operations, stability operations have been, are now, and will be, carried out across widely different types of terrain and environments. The National Command Authority (NCA) may want to employ URBAN SUNRISE at the nation state level, while a division commander may be interested in a specific urban area. Knowledge base structures and simulations should be able to accommodate the diverse environments in which stability operations are likely to occur, without the need for extensive modification and retraining.

- Area of interest - Actually a Populated Area of Interest (PAOI). URBAN SUNRISE should be capable of supporting stability operations in multiple types of PAOI's, and by various levels of command.
- Example - The Iraq case demonstrates that stability operations are occurring in a variety of types of areas, with policymakers, decision makers, commanders, and intelligence personnel interested in operations in all the types. In each one of these areas the specifics may be different, and there may be some unique elements; but there is a general set of characteristics that apply to all.
- Characteristics - These are only intended to be illustrative of the Iraq case. What is needed is a taxonomy of characteristics that works for all types of areas of interest. At least a core of area characteristics should be useful at all levels of a stability operations. This should contribute to aggregating data up as the tool is employed. A taxonomy of characteristics could include:
    - Physical: urban, desert, riverine, etc
    - Cultural-social: the people on the land, their linkages and processes

- Economy and infrastructure: commercial activity, transportation, communications
- Government and Administration: political structure, administrative units, etc
- Military-security: regular and irregular forces, crime, opposition and resistance elements
- Perceptions and attitudes: regarding US/coalition, regarding others, etc

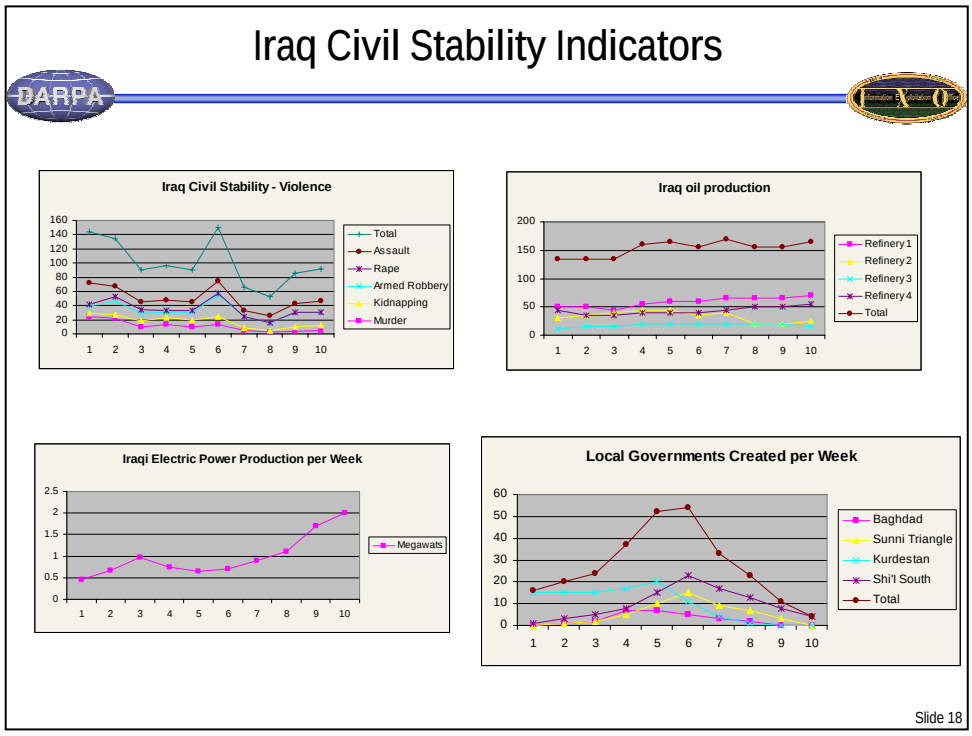


In Iraq, incremental progress on restoring the economy and infrastructure, establishing local government, and creating new and untainted security forces is often overshadowed by dramatic acts of resistance and terrorism. Because of this tendency for the dramatic to obscure the incremental adequate tracking measures for key issues related to stability must be developed, both for our ability to understand what is really important and to measure the success of stability related programs and operations. Four "macro-dimensions " of stability, which could be tracked and projected in URBAN SUNRISE, are suggested here. Doubtless, others could be devised

- Level of Security – Without question, security is the single most important factor in stability in Iraq. At least four dimensions of security could be tracked and analyzed: the number of resistance associated incidents over time, providing a rough indication of progress against the resistance; coalition casualties (Killed in Action, Wounded in Action KIA/WIA), providing an indication of the tactical effectiveness of resistance forces; resistance casualties, providing a similar indication of coalition effectiveness; and violent crime, suggesting the relative personal security of Iraqi citizens.
- Reconstruction Progress – The rebuilding of Iraq's key oil, electric power, and infrastructure elements is necessary for the long-term stability of the country. Failure to address this area effectively at the beginning of the occupation

contributed substantially to the lack of stability through the summer months. Tracking progress in reconstruction provides both a means of offsetting fleeting, but attention getting problems, and an objective measure of increasing quality of life for Iraqis.

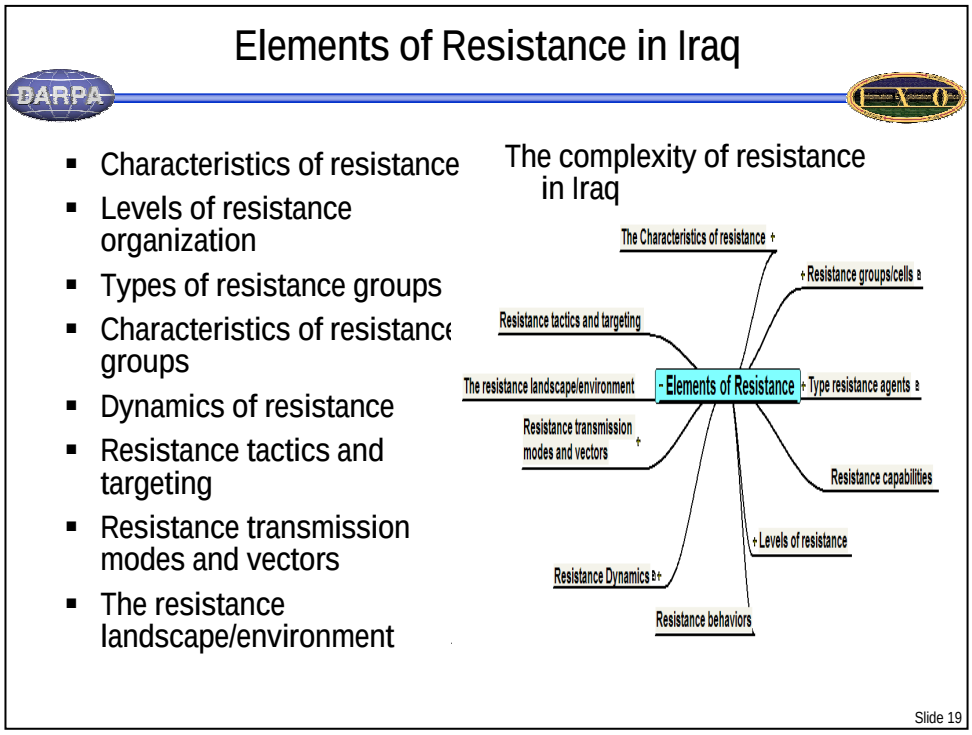
- Attitudes and Perceptions – Because stability very much depends on the active and tacit support of Iraqis - their "hearts and minds" - changes in the perceptions of Iraqis about the situation must be monitored, and projected in response to coalition plans and operations. The process of surveying opinion and attitudes should be systematized.
- Political Life - Replacing a corrupt and dictatorial regime with a government based on some form of democratic process and the rule of law is a critical component of stability in Iraq. Without this only force of arms can hold the country together. Measures of change in political life in Iraq could include the rate of creation for new government institutions, political activity within ethnic and sectarian communities, and the actions of the Iraq Governing Council (IGC).



Coalition planners might want to take multiple "looks" into the issue of stability to develop greater understanding of the situation, and to provide the basis for detailed stability operations planning. They could be interested, for example, in how stable Iraqi civil society is, with the issue of resistance excluded. Here to a number of measures could be devised. Four, with high saliency for Iraq, are suggested here.

- Violence – Much of the highly visible violence in Iraq is associated with resistance activities, but there is also a considerable amount of violent crime in Iraq, distinct from resistance to the occupation. Following trends in violent crime would permit assessments of the effectiveness of local security measures, especially the Iraqi police and judicial systems, key coalition stability associated programs.

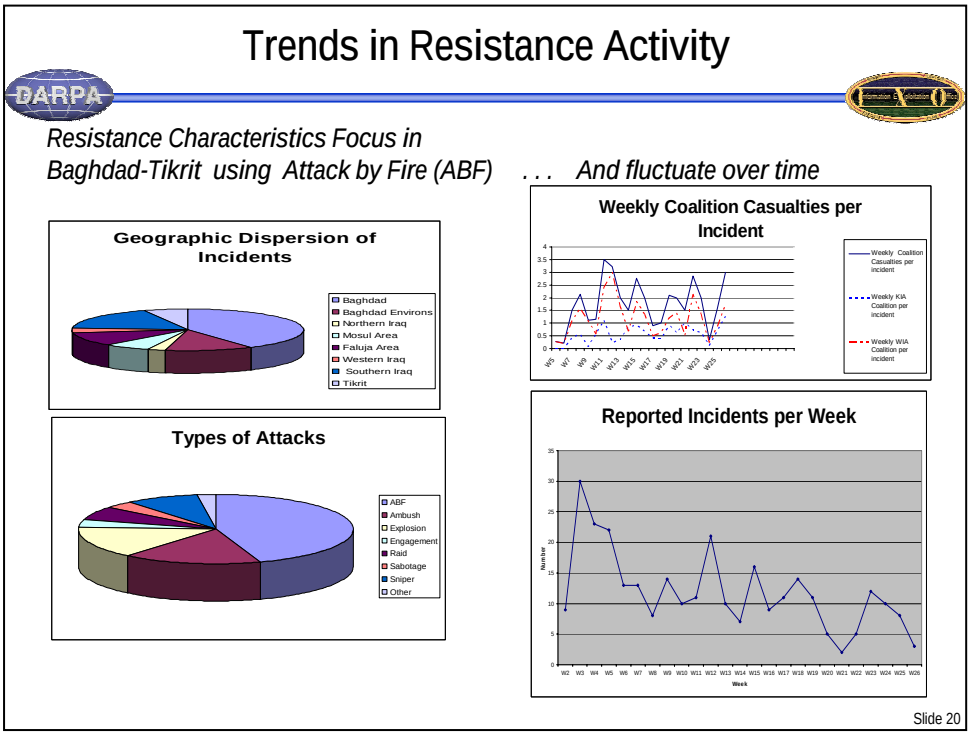
- Oil Production – The amount of oil being pumped is key to the future Iraqi economy, including employment and state revenue. Trends in oil production also provide an indicator of stability both in terms of the physical security of the petroleum system and investment in it.
- Electrical Power - Similarly, positive trends in power production suggest both the security of the power system, and an improvement in the quality of life. Quality of life being an essential element in winning "hearts and minds" and in establishing a solid basis for a transition to democratic Iraqi rule.
- Local Government – Dismantling a repressive regime which intruded into every nook and cranny of Iraqi life, and establishing the basis for a democratic system, has required the reestablishment of effective local government. Progress in this dimension could be effectively measured in a variety of ways and linked to other measures of political progress, such as diversity in representation and political participation (e.g. voting)



If security is essential to stability in Iraq, defeating, or perhaps more realistically controlling, the resistance is essential to security. Resistance in Iraq is in itself a complex phenomenon, that is, it is a complex adaptive system, evolving over time in response to changes in the environment, and whose outcomes are emergent rather than linear. This complexity is in part responsible for the difficulty the coalition has had in dealing with the resistance. Traditional analytic tools and approaches are not well suited for such a phenomenon.

- Characteristics of Resistance - The resistance is multiply inspired, locally based, principally comprised of small groups/cells, features local leadership and support structures, with only limited connections to other groups.
- Levels of Resistance - Resistance is occurring at the individual, local and regional levels. It is not yet a national phenomenon, although it could become so.

- Types of Resistance Groups – Resistance groups are functionally, motivationally, and organizationally diverse. Resistance actions suggest a degree of specialization.
- Characteristics of Resistance Groups – Resistance groups possess motivation, manpower and weapons assets and capabilities, and strategies and tactics. They pursue a variety of goals.
- Dynamics - The resistance operates in a number of dynamic relationships, including the requirement to conduct operations while avoiding destruction and to exist within Iraqi society while avoiding detection.
- Tactics and Targeting – Adaptation and evolution in these areas have been evident, providing a challenge to coalition forces.
- Transmission Modes and Vectors – Resistance is transmitted in various ways (vertical, horizontal, oblique)[6], and over various paths (sermons, road networks, written and taped messages).
- Landscape/environment - The resistance is active on a dynamically changing landscape or environment comprised of the many facets of the situation in Iraq. This landscape is "plastic", deforming in response to changes in the situation, and compelling the resistance to adapt.



Resistance activity needs to be tracked systematically in order to provide perspective and context for analysis. Building data overtime also supports analysis, projection, and simulation. The Iraq situation is providing rich data on an active resistance and its interactions with an occupying power and the people the resistance is embedded within. The data used here is unclassified from open sources. Much richer data is available to coalition forces and intelligence organizations.

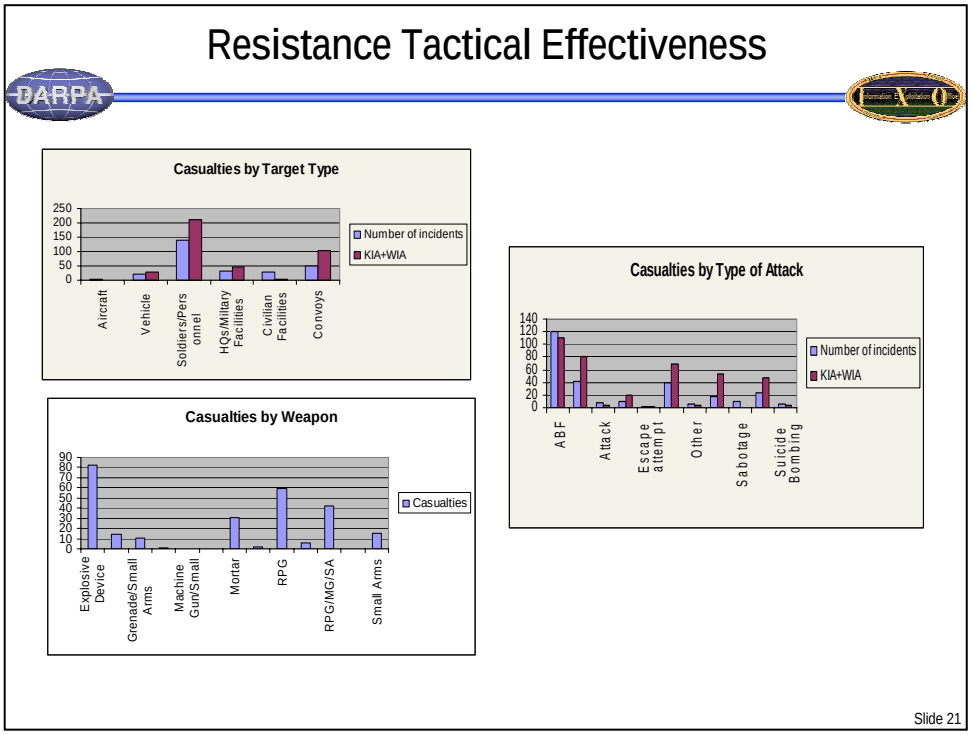
[6] See " On the Complexity of Cultural Transmission and Evolution" in Gowen, Pines, Meltzer (eds), *Complexity: Metaphors, Models, and Reality,* NY: Perseus, 1994.

- Weekly Coalition Casualties per Incident – This provides a long-term measures of how effective the resistance is in achieving its objective of inflicting casualties on coalition forces. By looking at casualties per week per incident it is possible to reduce the influence of a single casualty producing incident or to avoid focusing on a limited period of time.

- Geographic Dispersion of Incidents – In Iraq, where incidents are occurring and how many there are is important. Reporting consistently shows that resistance is largely a Sunni phenomenon, with the critical Shi'i dominated areas less effected, but not isolated from it. Tracking the geography of resistance also shows that it has spread over time and is continuing to spread.

- Types of Attacks – One characteristic of resistance in Iraq has been its evolution of new ways of attacking coalition forces. From a relatively few types of attacks at the beginning of resistance, there has been continuing diversification, again posing a challenge to coalition forces.

- Incidents per Week – The number of reported incidents per week has fluctuated over time. Tracking incidents per week provides an overall indication of the amount or frequency of resistance activity, and avoids the problem of fixating on recent events. Unclassified data shows that the frequency of incidents rises and falls in a wave shaped pattern.



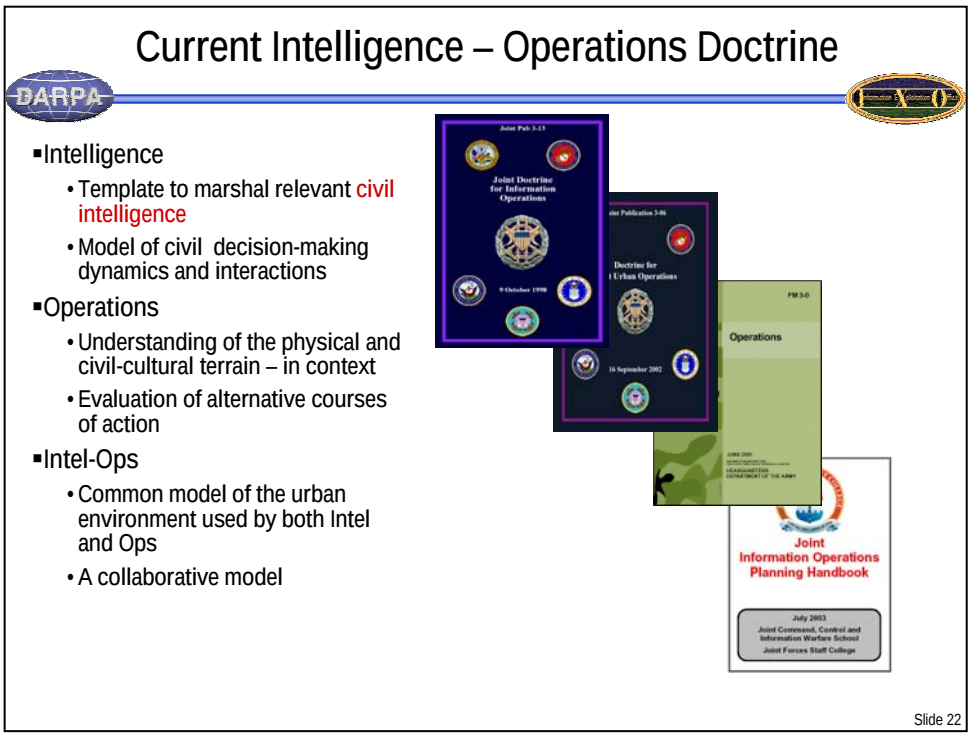
Understanding how the effectiveness of resistances at the tactical level is important to coalition commanders. The tactical flexibility of the resistance allows it to adapt to countermeasures by the coalition, and to continue to inflict losses. Adaptation by resistance elements can be tracked and operationally anticipated with appropriate data collection and analytical techniques.

One way to measure this is to examine the relative casualty producing effects of various types of resistance actions. There are of course other measures, but this kind of data can be readily and systematically captured in structure knowledge bases. Presumably much of this type of data is being collected now by coalition units.

Casualties by Target Type – Resistance targeting has evolved over time, with the categories of potential targets expanding and targeting preferences changing in response to changing conditions. Based on unclassified data, soldiers or other personnel, usually in the open as at checkpoints or on patrol, and convoys, especially soft vehicles, have been the targets of choice. Well protected facilities, and armored vehicles, including tanks and AFVs are not immune from attack.

Casualties by Type of Attack – The resistance employs different methods for attacking coalition targets. The most numerous type of attack has been an "attack by fire", basically shooting at coalition targets with various types of weapons, and these have produced the most casualties overtime. Ambushes and attacks with explosive devices have been the second and third most productive for the resistance.

Casualties by Type of Weapon – Resistance elements are employing a variety of weapons, increasingly in combination. Based on unclassified data, the most effective weapons have been explosive devices, and Rocket Propelled Grenades, used either alone or in combination with other types of weapons.



The current U.S. intelligence and operations doctrine for urban warfare is defined in a number of Joint and Army publications including:

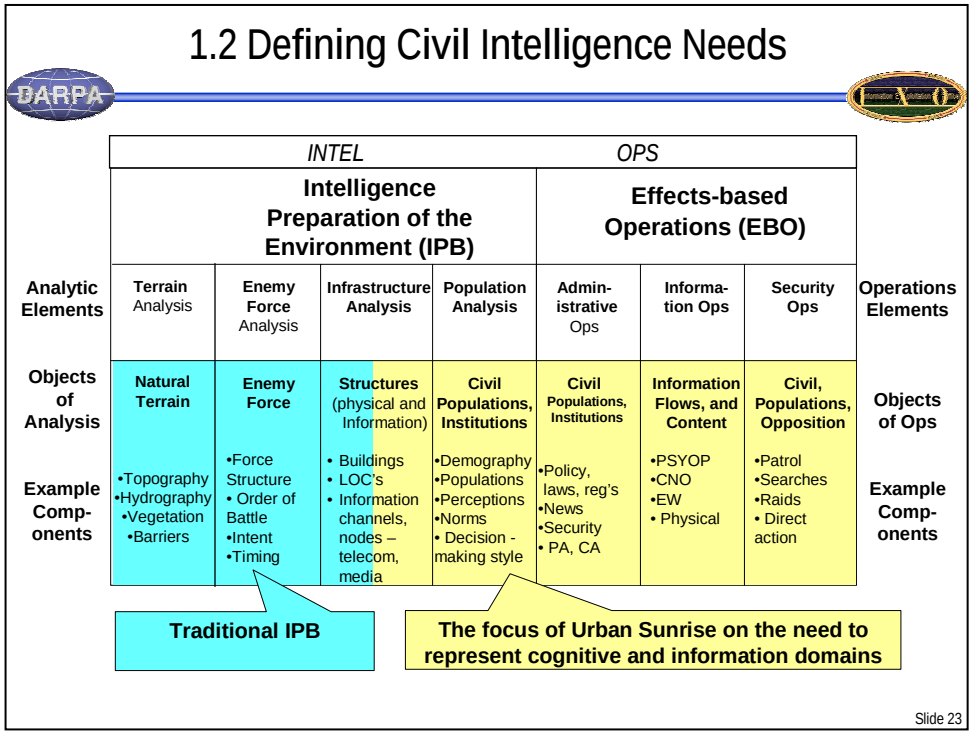
The current intelligence approach is to develop and apply standard (spatially or map oriented) templates to marshal relevant civil intelligence. Urban Sunrise expands the collection and marshalling of such civil information and introduces a model of civil decision-making dynamics and interactions.

The current military operations approach emphasizes understanding the physical and civil-cultural terrain – in context, and then the traditional evaluation of alternative courses of action. Urban Sunrise adds the capability to conduct sophisticated EBO simulations to evaluate the potential effects of alternative courses of action (COA's).

Urban Sunrise also supports the collaborative operation of Intel-Ops through the use of a common knowledgebase and common model of the urban environment for use by both Intel and Ops.

1.2. Defining Foreign Civil Intelligence Needs

The needs for foreign Civil Intelligence in both intelligence and operations are described in this section, enumerating specific statements by DoD organizations. The civil intelligence needs are distinguished from traditional military intelligence needs and the recommended users of Urban Sunrise capabilities are described.



Traditional Intelligence Preparation of the Battlespace (IPB) focuses on the development of information on physical terrain, enemy force dispositions, and aspects of infrastructure that influence and constrain symmetric force-on-force combat operations (e.g. FM 90-10 Appendix A Urban Terrain Analysis). These areas (in blue above) are supplemented by population analysis – considered by the Army to be a component of the urban terrain. Population analysis includes the following categories and factors:[7]

> General Lines of Division: political, economic (including land ownership), ethnic/racial/tribal/religious, education, health, welfare, language, and key personalities
>
> Host Nation (HN) Government Lines of Division: structures, key personalities, parties and factions, perceived legitimacy, special interest groups, foreign policies
>
> HN Military Lines of Division: normal order of battle (OB) factors and personalities, loyalties and affiliations, relationship with identified divisions

[7] FM 34-7, includes a detailed description of population analysis elements, pp. 3-5 to 3-8.

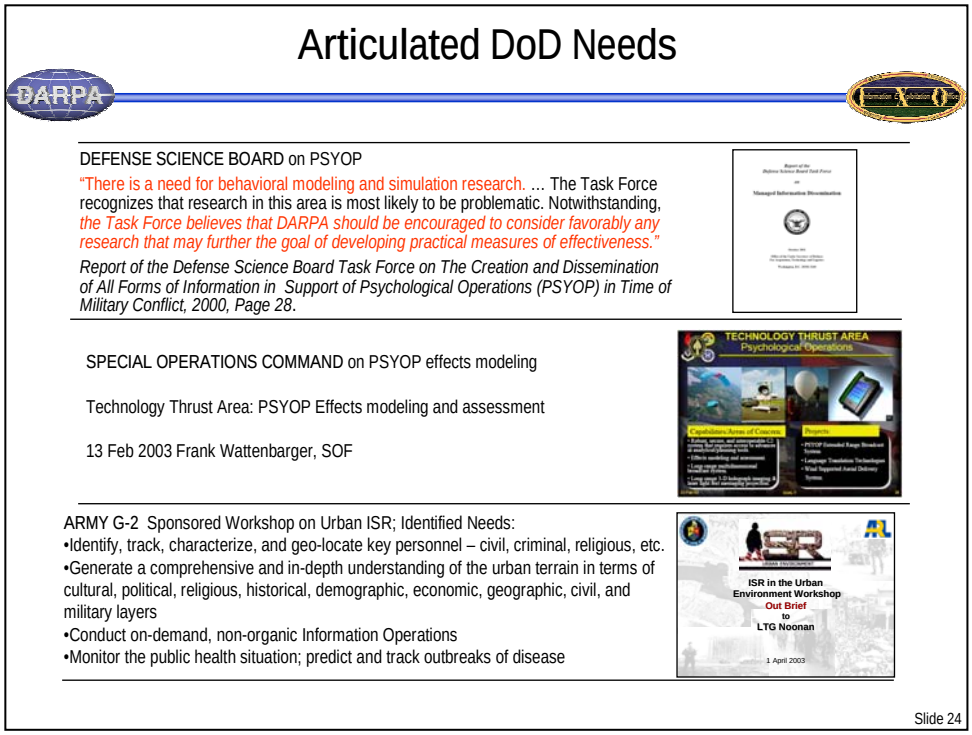
in the civil populace, ability to complete mission, consider as threat for later analysis

In addition to the IPB component of Urban Sunrise capabilities, the operations component includes EBO simulation of effects for three categories of operations:

Administrative Operations: host nation administration and military civil affairs operations (economic, social, regulatory, etc.)

Information Operations: Includes the complete set of IO (PSYOP, electronic ops, computer network ops, military deception) and related civil and public affairs affiliations.

Security Operations: Military security, up to and including military operations.



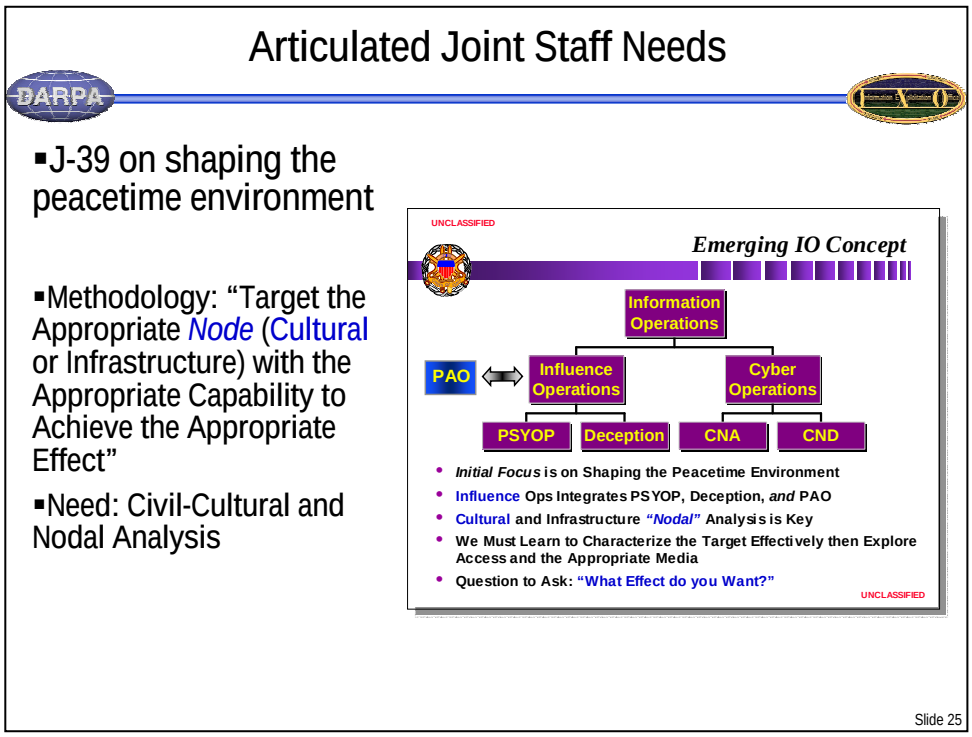
Organizations within the DoD have clearly articulated the need for Urban Sunrise capabilities. Consider three specific examples. The Defense Science Board as identified the need for effects based simulation and measurement of PSYOP effects on civil populations, recommending, "There is a need for behavioral modeling and simulation research. … The Task Force recognizes that research in this area is most likely to be problematic. Notwithstanding, *the Task Force believes that DARPA should be encouraged to consider favorably any research that may further the goal of developing practical measures of effectiveness."*[8]

[8] Report of the Defense Science Board Task Force on The Creation and Dissemination of All Forms of Information in Support of Psychological Operations (PSYOP) in Time of Military Conflict, 2000, Page 28.

Similarly, the Special Operations Command (SOCOM) has identified PSYOP effects modeling and assessment as a critical technology thrust area.[9]

A 2003 **ARMY G-2** sponsored Workshop on Urban Intelligence, Surveillance and reconnaissance (ISR), identified the following items as key needs:[10]

- Identify, track, characterize, and geo-locate key personnel – civil, criminal, religious, etc.
- Generate a comprehensive and in-depth understanding of the urban terrain in terms of cultural, political, religious, historical, demographic, economic, geographic, civil, and military layers
- Conduct on-demand, non-organic Information Operations

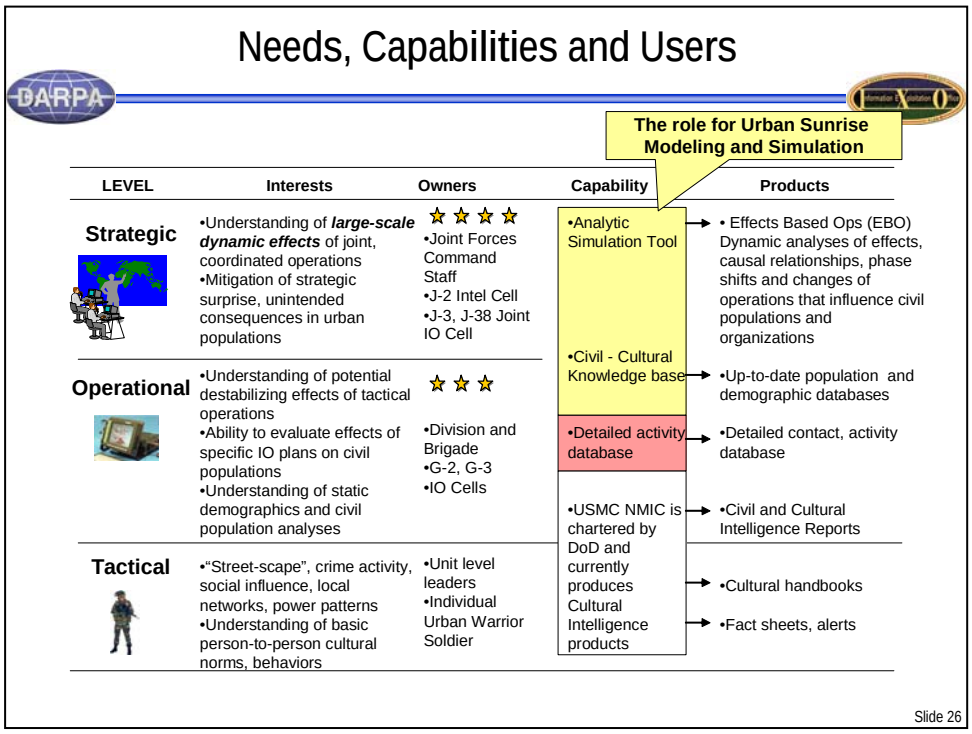


The Joint Staff (J-39) has also identified key IO needs for shaping the peacetime environment. Essential to the EBO methodology is the need to "Target the Appropriate *Node* (Cultural or Infrastructure) with the Appropriate Capability to Achieve the Appropriate Effect." This requires civil-cultural nodal analysis as described in this report.[11]

[9] SOCOM Technology Briefing, Frank Wattenbarger, SOF, 13 Feb 2003.

[10] ISR In the Urban Environment Workshop Outbrief to Lt. Gen. Noonan, 1 April 2003.

[11] Information Operations Briefing, Colonel Jack N. Summe, Information Strategy Division, Directorate for Information Operations, Joint Staff, J-39 ISD, March 1999.

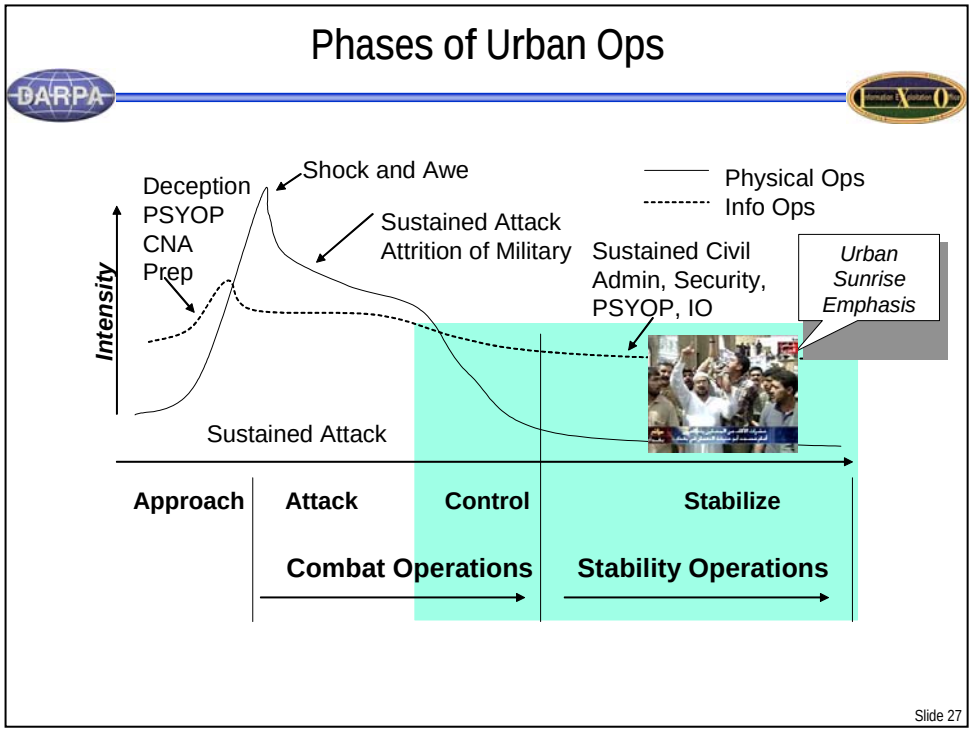


Urban Sunrise is focused on the strategic and operational level needs (Joint forces command and division, respectively) for civil intelligence. It provides the needed strategic assessment of civil populations, their characteristics, attitudes, trends and current activities.

At the strategic level, Urban Sunrise capability will provide an understanding of ***large-scale dynamic effects*** of joint, coordinated operations on civil populations, helping to mitigate the risk of strategic surprise, and unintended consequences in urban populations.

At the operational level, Urban Sunrise will aid in the understanding of potential destabilizing effects of tactical operations, providing the ability to evaluate effects of specific administrative, security and IO plans on civil populations. Complementing current USMC CETO and NMIC population and cultural studies, Urban sunrise will provide a knowledge base of dynamic demographics and civil population analyses.

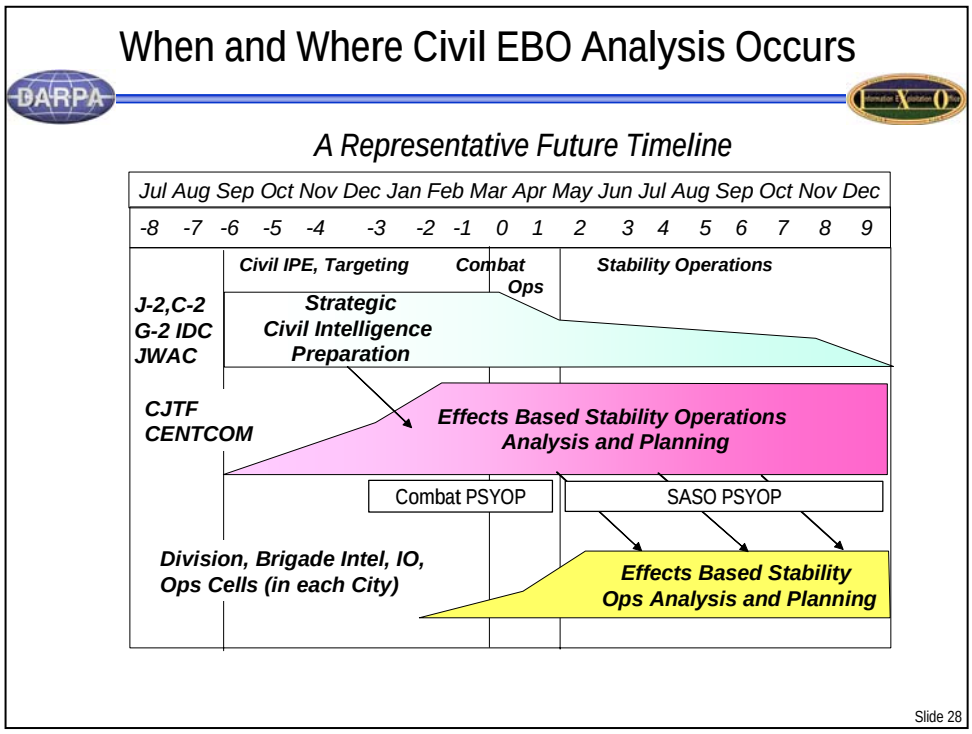
At the tactical level USMC CETO supports the development of training and tools to aid urban warriors to be culturally aware and "Street-smart", understanding the basic person-to-person cultural norms and behaviors. Urban Sunrise may even help at this level, providing knowledge of activities and trends in crime activity, social influence, local networks, and power influence patterns.



Urban Sunrise capabilities encompass the entire range of operations from pre-combat preparations, through stability operations and peacekeeping. The notional intensity of operations across a typical wartime scenario illustrates the transition form combat to stability operations and the focus of Urban Sunrise activities in Stability and Support Operations (SASO). The roles of Urban Sunrise are envisioned as follows:

- Pre-Combat – In the pre-combat phase, Intelligence Preparation begins and the Civil Intelligence knowledge base is populated with necessary data to create an understanding of civil populations and institutions. In the approach phase, the EBO simulations are used to support PSYOP activities that use CNO and other broadcast media to transmit themes and messages to civil populations.
- Combat - In combat phases, civil population are monitored and the knowledgebase is updated to track responses to PSYOP and combat operations.
- Stability Operations – In this phase, the Urban Sunrise capability supports EBO simulations of the effects of administrative (Civil affairs) actions, and coordinated IO and Security operations to counter opposition forces, and opposition groups embedded within the civil population. “Stability operations and support operations demand greater attention to civil considerations—the political, social, economic, and civil factors in an area of operations (AO)—than do the more conventional offensive and defensive operations. Commanders must expand intelligence preparation of the battlefield beyond geographical and force capability considerations …. Success in these operations requires multidisciplined, all-source, fused intelligence.” [12]

- [12] Source of Quotation: FM-3-07 para 2.7. 2.8



A representative future timeline illustrates how Urban Sunrise might be employed in a pre-combat through to stability operations scenario.

Strategic Civil Intelligence Preparation - At six-months prior to combat operations, a Joint intelligence cell, comprised of J-2, G-2, DIA and JWAC personnel begins the intense creation of the intelligence preparation of the urban environment process. This process might be hosted at the INSCOM Information Dominance Center (IDC), populating the knowledgebase from intelligence sources, and issuing intelligence tasking to complete gaps in knowledge. Throughout all phases, this team will support the strategic collection and population of the common knowledgebase used by all.

Combined Joint Task Force – The knowledge base and EBO tools will be integrated by INSCOM IDC and transitioned to CENTCOM JTF operators as pre-combat PSYOP campaigns are planned, executed and EBO models are refined as a result of measured responses. At this level, JTF J-2 and IO Cells will use the Urban Sunrise capability to analyze the status and effects on civil populations, and plan future operations.

Division and Brigade G-2 and IO Cells – In each large Urban Area of Operational Responsibility (AOR), customized knowledge bases and EBO simulations will aid local intelligence analysis and operations planning.

Stability Operations

Purpose: **Combatant commanders employ Army forces to conduct stability operations outside the US and US territories to promote and protect US national interests by by influencing political, civil, and military environments and by disrupting specific illegal activities.**

FM 3-0 2000

Chapter 9 Stability Operations Major Points:

- **Defines Stability Operations**
  - **Link to combatant commander's strategy**
  - **Complex, dynamic, asymmetric environment**
  - **Nonlinear & noncontiguous**
  - **Theater Engagement Plan (TEP)**
  - **Regional Stability is a function of security and economic prosperity**
- **The Army's Role in Stability Operations**
  - **Peacetime Military Engagement**
  - **Rapid Response & Preclusion (SSC)**
  - **Presence/Deterrence**
- **Types of Stability Operations**
- **Considerations for Stability Operations**

Urban Sunrise Focus: Understanding the Dynamics to support Effects based Ops

Source: TRADOC ***The Objective Force: Foundations of Transformation and The Objective Force Concept***

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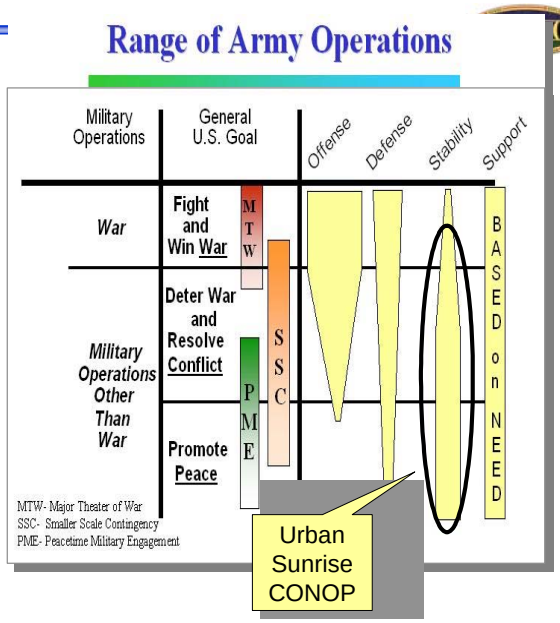
Urban Sunrise Within Range of Army Operations

DARPA

"Stability operations and support operations demand greater attention to civil considerations—the political, social, economic, and civil factors in an area of operations (AO)—than do the more conventional offensive and defensive operations. Commanders must expand intelligence preparation of the battlefield beyond geographical and force capability considerations.... Success in these operations requires multidisciplined, all-source, fused intelligence." FM-3-07 para 2.7. 2.8



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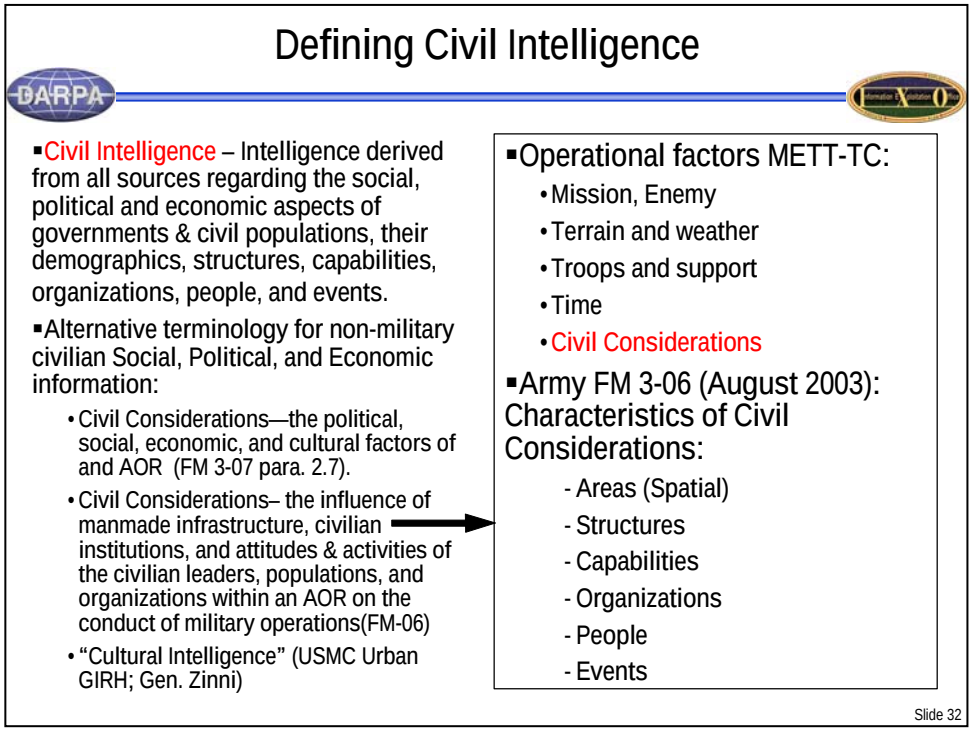
2. TECHNICAL APPROACH

The recommended technical approach to implement the Urban Sunrise functional and operational capabilities is described in this section, moving from the definition of foreign civil intelligence and CONOPS before detailing the technical components.

2.1. Defining Foreign Civil Intelligence

We define Civil Intelligence as *that intelligence derived from all sources regarding the social, political and economic aspects of governments & civil populations, their demographics, structures, capabilities, organizations, people, and events*.

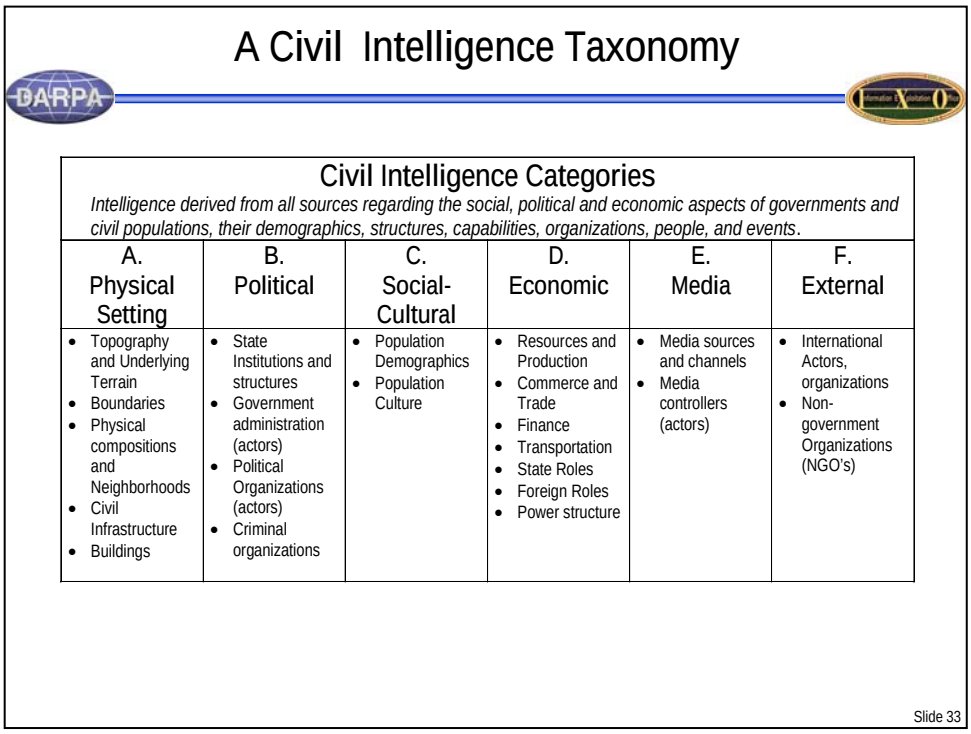


This definition has been carefully selected to remain consistent with DoD practice and Army FM 3-06 which explicitly describes "civil considerations" as an operational factor critical to military operations. The alternative terminology considered for non-military civilian Social, Political, and Economic information includes:

- •Civil Considerations—the political, social, economic, and cultural factors of and AOR (FM 3-07 para. 2.7).
- •Civil Considerations– the influence of manmade infrastructure, civilian institutions, and attitudes & activities of the civilian leaders, populations, and organizations within an AOR on the conduct of military operations(FM-06)
- •"Cultural Intelligence" (Term used in USMC *Urban Generic Information Requirements Handbook* GIRH; also used by Gen. Anthony Zinni [13])

[13] "… the lesson learned [in Somalia] that kept coming out was that we lacked cultural awareness. We needed cultural intelligence going in." Gen Anthony Zinni (USMC Ret.) National Defense University, August 8, 1996

A basic taxonomy of the components of civil intelligence is provided in the following chart.



A Civil Intelligence Taxonomy

Civil Intelligence Categories

Intelligence derived from all sources regarding the social, political and economic aspects of governments and civil populations, their demographics, structures, capabilities, organizations, people, and events.

A. Physical Setting	B. Political	C. Social-Cultural	D. Economic	E. Media	F. External
• Topography and Underlying Terrain • Boundaries • Physical compositions and Neighborhoods • Civil Infrastructure • Buildings	• State Institutions and structures • Government administration (actors) • Political Organizations (actors) • Criminal organizations	• Population Demographics • Population Culture	• Resources and Production • Commerce and Trade • Finance • Transportation • State Roles • Foreign Roles • Power structure	• Media sources and channels • Media controllers (actors)	• International Actors, organizations • Non-government Organizations (NGO's)

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The taxonomy includes six basic categories of information required by analysts and operations planners:

A. Physical Setting – includes the topography and underlying terrain, the boundaries of defined areas and demographics, physical compositions and neighborhoods, civil infrastructure, including key civil buildings

B. Political – factors include state institutions and structures, government administration (actors), political organizations (actors), and criminal organizations

C. Social Cultural – factors include population demographics and culture.

D. Economic – factors include resources and production, commerce and trade, Finance, transportation, state roles, foreign roles, and economic power structure

E. Media – includes media sources (e.g. reporters), channels (e.g. Al Jazera), and controllers (e.g. actors, the owners of Al-Jazera).

F. External – includes information about international actors, organizations, and non-government organizations (NGO's) that influence the civil populations.

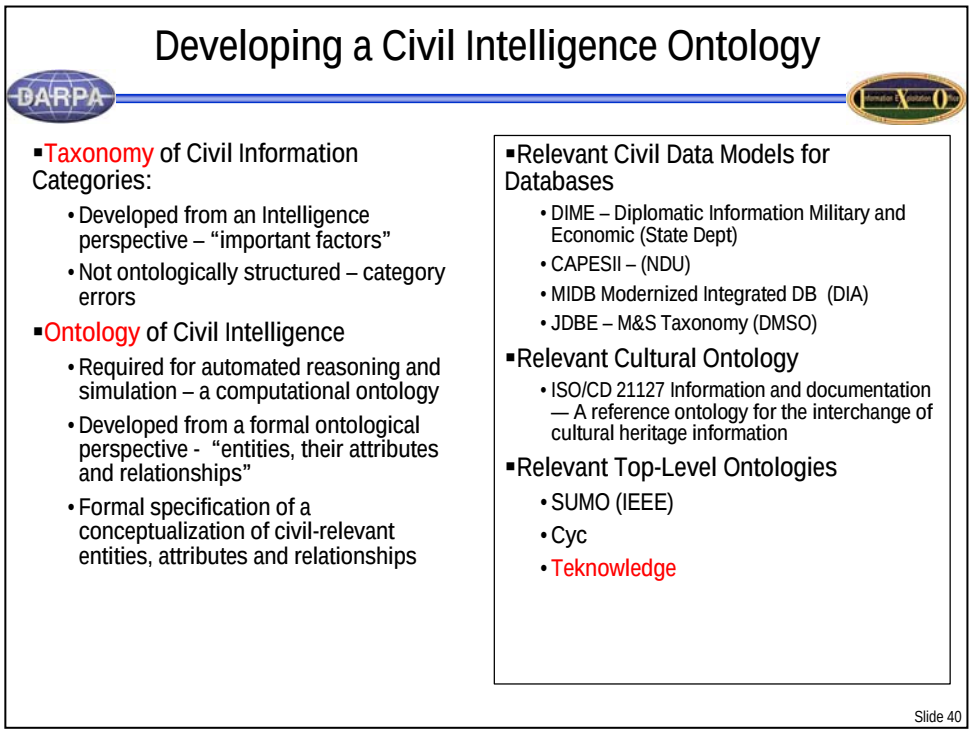
The table that extends across the following three pages enumerates the extended taxonomy of subcategories of civil intelligence information.

COMPONENTS OF FOREIGN CIVIL INTELLIGENCE

Area	Component Elements
A. Physical Setting	▪ Basic topography & underlying terrain, including boundaries •Natural •Political, administrative, demographic ▪ Urban area physical compositions & neighborhoods ▪ Infrastructure (civil perspectives, physical components) •Transportation - Formal - Paratransport ▪ Buildings •Construction details, as necessary •Significant buildings or places ▪ Telecommunication networks (*physical* structure) •State, private ▪ Utilities •Electric power •Gas •Water supply •Sanitation •Food supply •Fuel supply
B. Political	▪ State (Institutions, structures) •National, regional •City, urban area - Relationship with national state - Associated state actors in urban area, if any - Local military garrisons & infrastructure - Local national frontier zone, border or coastline - Relationship to hinterland ▪ Government, administration (Actors) - Local state industries and corporations •National, regional •City, urban area - Power structure, crony/family connections - Public services - Schools - Utilities - Security/Law & order /Public safety - Police, gendarmerie, prisons, criminal courts - Fire fighting, traffic regulation, civil defense - Social control ⇘ Domestic intelligence gathering & operations ⇘ Political/communal repression •Key personnel ▪ State administrative & policy activities ▪ Political organizations (parties, movements, factions, other groups) •Types - Secular, ideological - Social class - Economic interest (including criminal fronts) - Ethnic, racial, tribal, clan - Religious - Personality-centered - Other •Stances - Wrt government (some play here about legitimacy [a 'perception']?) - Incumbent governing party/coalition - Cooperation, co-optation, penetration, rent-seeking - Opposition, partial substitution (Non-violent, orderly) - Obstruction (Resistance) - Other - Wrt other political groups, social groups •Key personnel ▪ Political & administrative activity ▪ Political communications ▪ Political statements

<table>
<tr><td rowspan="3">C. Social-Cultural</td><td rowspan="2">Population Information</td><td>Demography
▪ Population count & density, by urban area or neighborhood, & non-urban hinterland
•Age
•Gender
•Ethnic groups
•Races
•Religions
•National origins
•Tribes/clans
•Economic classes, wealth distribution
▪ Population movements
•Normal migrations
•Immigration
•Refugees, IDPs, evacuees</td></tr>
<tr><td>Culture
▪ Languages
▪ History, development of city, region & nation-state
▪ Religions (beliefs & institutions)
▪ Social groups
•Ethnic, race, tribe/clan, religious
•Segmentation, distribution, history, power
•Leaders, elites, followers
•Relationships with state, groups
▪ Customs, attitudes, social taboos
▪ Social roles of population segments (women, elders)
▪ Cultural ‘styles’
•Negotiating
•Persistent, historically-based perceptions, outlooks, temperaments
•Distinctive organizational behavior (political, economic, social)
▪ Culturally significant locations
▪ Dates, events</td></tr>
<tr><td rowspan="2">Activity Information</td><td>Humanitarian
▪ Local status of human needs (food, water, medical, shelter, security)
▪ Political repression, social conflict
▪ Refugee, IDP, evacuee status</td></tr>
<tr><td>Criminal
▪ Types
▪ Perpetrators
•Organized crime
- Structure
- Functional specialization
- Roles of political actors, if any
•Gangs, other groups
•Individuals, popular action
▪ Victims
•Individuals, social groups
•State entities
•Economic entities
▪ Motives
▪ Times, places, locations</td></tr>
</table>

D. Economic	▪ Key local resources & materials production ▪ Commerce & trade ▪ Finance & banking •Private sector •Government, including currency, revenue collection, investment & spending ▪ State roles or participation (national, regional or local) ▪ Foreign, multinational corporations or commercial presence ▪ Status of basic economic needs of the population ▪ Economic crime? ▪ Power structure aspects, formal & informal •Organizations & individuals - Business & professional organizations - Business, landed elites - Labor/peasant unions - Other •Influences & alliances ▪ Activities, including government regulation
E., Media/Public Information	▪ Actors •Broadcasting/publishing/website organization - Local, foreign (including US) - State and private - Transmission sites, if relevant •Owners/operators/interested parties - State and private - Political orientation, role •Content originators (political/social groups, writers, producers) ▪ Messages •Time of dissemination, location if relevant •Medium (includes electronic, print, speeches/harangues, maybe rumor) •Intended audience(s) ▪ Message Contents •Events, activities •Assertions, declarations, threats •Actors •Times, places •Opinions, stated or implied perceptions
F. International Organizations and NGO's	▪ Structure, international, nationwide & local ▪ Roles, local missions •Projects •Political orientation •Activities •Reporting, publications, information dissemination ▪ Personnel •Nationality •Assignment •Other personal data ▪ Local areas of operation •Offices •Work locations, distribution points, etc. •Residences of personnel ▪ Relations with other groups •Local social, economic organizations, neighborhood bodies •Population groups •Urban authorities •Political parties, factions



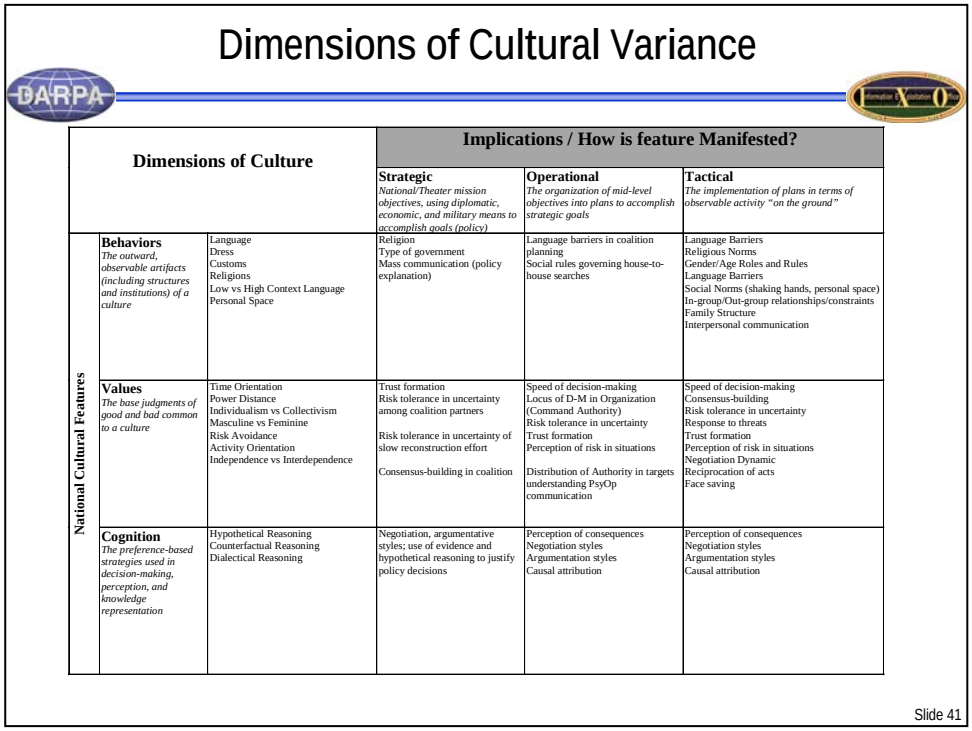
The taxonomy of Civil Intelligence is valuable for intelligence analysis; it was developed from an intelligence perspective, defining the "important factors" for studying civil populations. The taxonomy, however is not ontologically structured – it contains logical and category errors that render it insufficient (or incompletely described) to support computational understanding necessary for automated analysis and auto-population of the EBO simulation.

An ontology of Civil Intelligence is required for automated reasoning and simulation – a computational ontology is required to be developed from a formal ontological perspective that defines "entities, their attributes and relationships" with a formal specification of a conceptualization of civil-relevant entities, attributes and relationships. There exist several relevant Civil Data models for databases that may provide a baseline for Urban Sunrise:

- DIME – Diplomatic Information Military and Economic (State Dept)
- CAPESII – (National Defense University)
- MIDB Modernized Integrated DB (DIA)
- JDBE – M&S Taxonomy (DMSO)

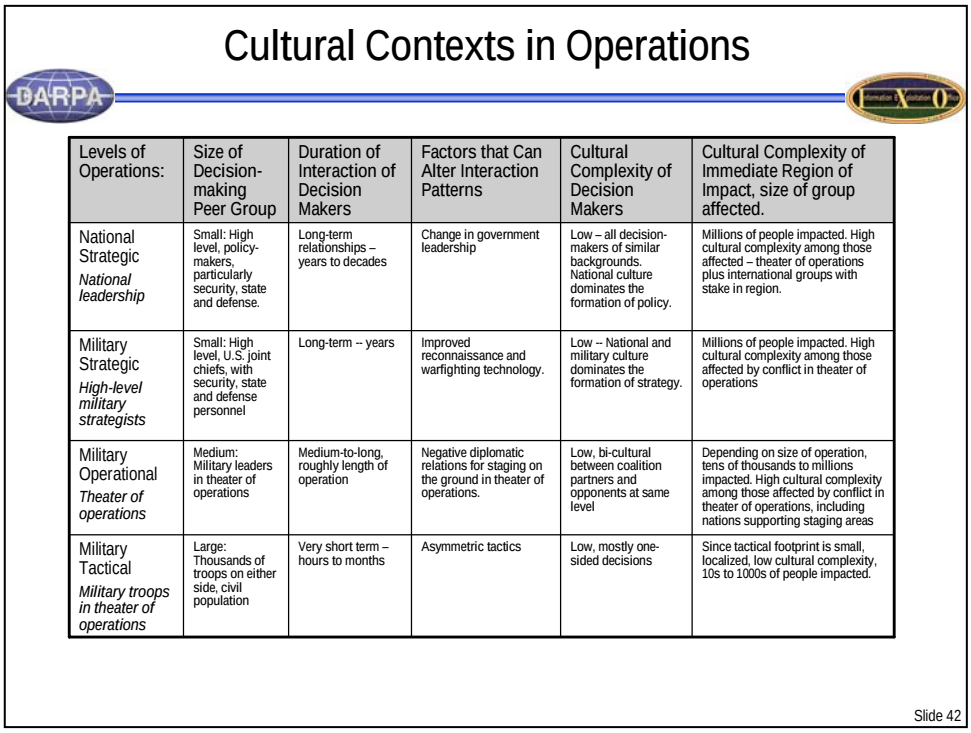
In addition, there exists potentially relevant cultural (anthropology) reference ontology for the interchange of cultural heritage information - ISO/CD 21127 Information and documentation.

These "domain ontologies" may form a foundation for development of an Urban Sunrise ontology that may be adapted to conform to available higher level ontologies, including SUMO (IEEE), Cyc, or others.



National culture, from a psychological or sociological perspective, is the set of shared traits that are passed down through members of a group. These traits tend to be slowly changing, and so can be understood well in advance of military operations. Typically definitions divide cultural differences into three broad categories: Behaviors (the observable traits such as customs, language), Values (beliefs about good and bad), and Cognition (strategies used in decision-making). Behaviors are the most obvious differences between cultures: language, dress, customs, and social rules are all quite visible when studying another culture. It is clearly necessary to understand what these differences are, and how to act in a culturally sensitive manner when dealing with a person from another culture. A review of military literature, such as Army Field Manuals and Marine Corps X-Files, suggests that an awareness of cultural behavior differences is present in training, though groups like Army Special Forces is much more informed than conventional forces, and more likely to employ this information in their dealings with native groups. Much research has been invested in the identification of universal characteristics of cultural values. Researchers have identified a number of distinct dimensions along which national cultures can be measured. In the last decade or so, new research has identified regularities in cognitive styles, including perception and problem solving strategies. Value differences, in an ad hoc fashion, are sometimes known about a target area of interest, and soldiers can be informed before deployment. However, cognitive differences, perhaps because of the newness of the research or the level of understanding required to utilize the information, do not appear in military literature in any formal way.

Despite the fact that this sort of information is slowly making its way into training, the employment of this information is still considered “unconventional” and, as such, that is where most of the use of it comes. Little of this information is taken into account in planning, and automated tools to assist planning tend to ignore these details.

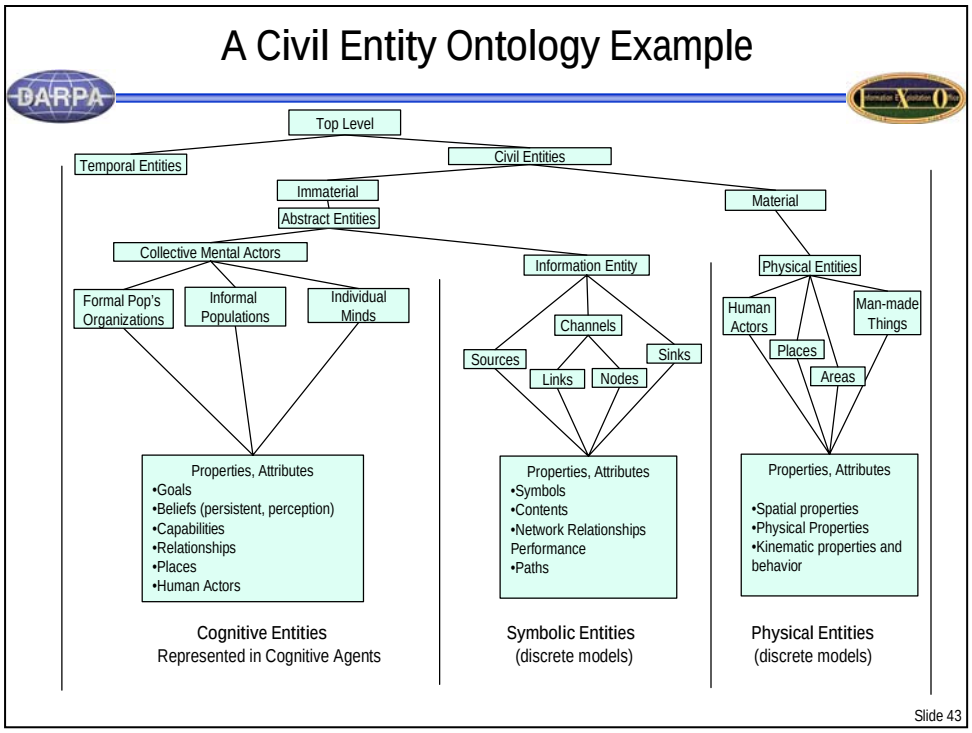


Levels of Operations:	Size of Decision-making Peer Group	Duration of Interaction of Decision Makers	Factors that Can Alter Interaction Patterns	Cultural Complexity of Decision Makers	Cultural Complexity of Immediate Region of Impact, size of group affected.
National Strategic *National leadership*	Small: High level, policy-makers, particularly security, state and defense.	Long-term relationships – years to decades	Change in government leadership	Low – all decision-makers of similar backgrounds. National culture dominates the formation of policy.	Millions of people impacted. High cultural complexity among those affected – theater of operations plus international groups with stake in region.
Military Strategic *High-level military strategists*	Small: High level, U.S. joint chiefs, with security, state and defense personnel	Long-term -- years	Improved reconnaissance and warfighting technology.	Low -- National and military culture dominates the formation of strategy.	Millions of people impacted. High cultural complexity among those affected by conflict in theater of operations
Military Operational *Theater of operations*	Medium: Military leaders in theater of operations	Medium-to-long, roughly length of operation	Negative diplomatic relations for staging on the ground in theater of operations.	Low, bi-cultural between coalition partners and opponents at same level	Depending on size of operation, tens of thousands to millions impacted. High cultural complexity among those affected by conflict in theater of operations, including nations supporting staging areas
Military Tactical *Military troops in theater of operations*	Large: Thousands of troops on either side, civil population	Very short term – hours to months	Asymmetric tactics	Low, mostly one-sided decisions	Since tactical footprint is small, localized, low cultural complexity, 10s to 1000s of people impacted.

There are multiple ways to look at the contexts in which cultural factors play a role in military operations. The table above looks at five characteristics of cross-cultural interaction in the four contexts of National Strategic, Military Strategic, Military Operational, and Military Tactical.

In national contexts such as National Strategic and Military Strategic, the number of decision-makers is quite low, consisting of people such as the national leadership, advisors, and military strategists. The members of these groups typically share the same culture, so the cultural complexity of the interactions is low. The members of these groups tend to work together for long periods of time, being members of same political parties, military command structures, or even leadership administrations. As they are in leadership positions, the decisions they make, especially having to do with decisions about conflict, tend to impact many people. On the other end of the spectrum is the Military Tactical, where a small group of peers, likely of the same National culture, make decisions that impact small groups of people, on the order of small firefights to neighborhoods.

Outside the immediate area of impact, modes of communication can spread impact, depending on the mode's efficiency in getting information out, and the regions that can be reached by that mode. For example, if there is broadcast news media present to witness tactical operations, the area of impact is now roughly equivalent to the area reached by the viewing area of that media outlet.



A civil entity ontology structure that may be considered for Urban Sunrise is depicted above. The ontology includes the following characteristics:

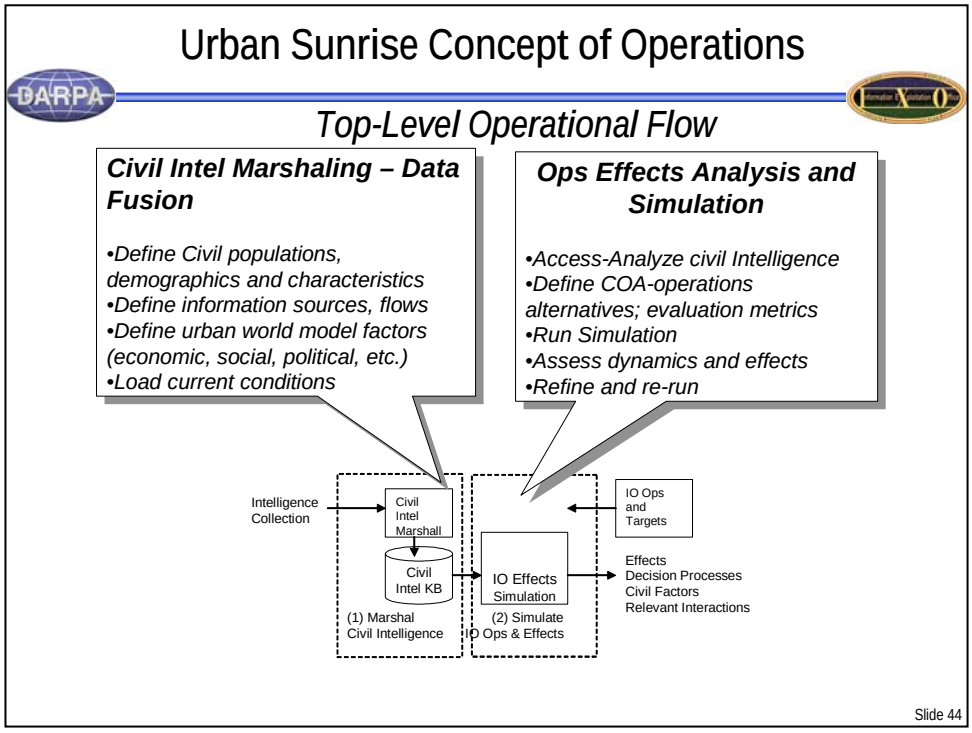
- Three Domains – the basis of the ontology is the three domain structure described earlier, distinguishing the material (physical domain) entities from two immaterial domains (the cognitive domain and symbolic or information domain).

- The ontology may be related to the earlier taxonomy components that break out the categories of human populations (organizations, institutions, etc.), information infrastructure,(media, flows and symbolic content) and physical infrastructure.

- The ontology distinguished between entities modeled and simulated by agent-actors (cognitive domain), entities modeled and simulated by information models, and entities represented in the physical world.

2.2. Concept of Operations

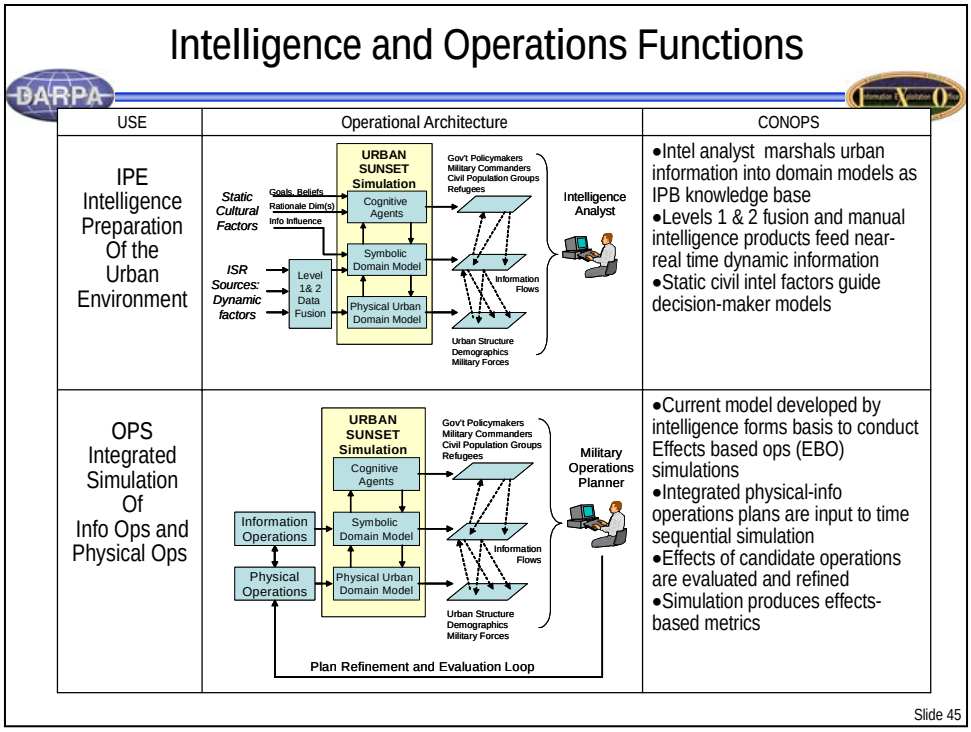
In this section, we introduce the concept of operations (CONOPS) for the Urban Sunrise capability to illustrate the anticipated application within the military context.



Two phases of activity are performed as civil intelligence is collected and provided as inputs to the system:

Civil Intel Marshaling–Data Fusion – is the first phase, in which automated and semi-automated processes accept the incoming information to define civil populations, and describe their demographics and characteristics. The urban information sources and flows are also characterized to understand the means by which each population group perceives situations and events. The urban world model factors (economic, social, political, etc.) are also described. All of these activities support the construction of a civil intelligence knowledge base of analysts to access, and to semi-automatically populate the agent based simulation model of the urban area. The current intelligence is also used to load the current conditions in the urban area.

Ops Effects Analysis and Simulation – is the second phase in which operations planners simulate anticipated actions and evaluate the predicted outcomes (effects). Operations planners can access-analyze civil intelligence to asses the key factors, then define course of action (COA) operations alternatives; and important effects evaluation metrics. The planners run the simulations, assess dynamics and effects, then refine and re-run to consider potential unintended consequences.



The two intelligence and operations phases are detailed in the chart above, showing the common core of the civil intelligence knowledgebase and EBO simulation. The illustration shows the three domains of the simulation:

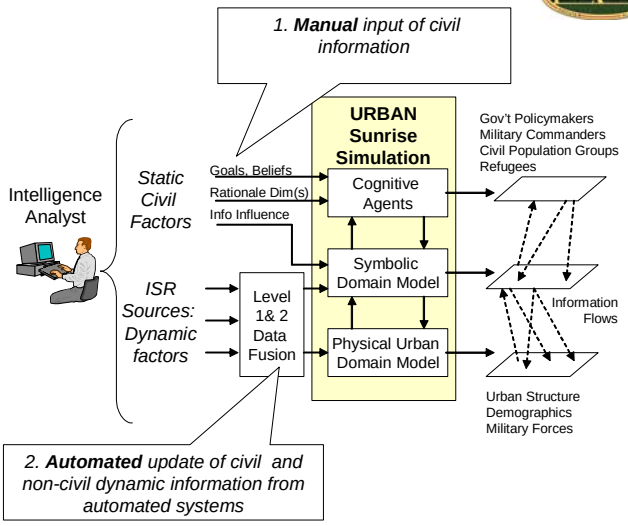
- Cognitive representations of population groups, simulated by interacting agent based simulation
- Information domain representing the media that provide information to the population groups, their inter-communications, and information flows.
- Physical domain represented on a geospatial map of the urban area, with dynamic time discrete models of movements and activities.

In the **Intelligence Preparation of the Urban Environment** phase, the intelligence analyst marshals urban information into domain models forming the IPB knowledge base. Levels 1 and 2 (civil object and civil situation refinement) fusion processes and manual intelligence products feed near-real time dynamic information into the process. The resulting civil intelligence knowledge base provides static civil factors for use by intelligence analysts to create urban current intelligence reports for military and civil administrative decision-makers.

In the **Operations Planning** phase, the current urban area model developed by intelligence forms the basis to conduct Effects based ops (EBO) simulations. Integrated administrative-physical-info operations plans are input to time sequential simulation and the effects of candidate operations are evaluated and refined. The simulation produces effects-based metrics that allow planners to measure quantitative effects in each of the three domains.

Intel Stage: Civil Intelligence Marshaling

- Evidence Accrual
- Explicit representation of Civil Intelligence
  - Text reports
  - Parametric data
- Annotation of structures, leaders, Irregular Tactics



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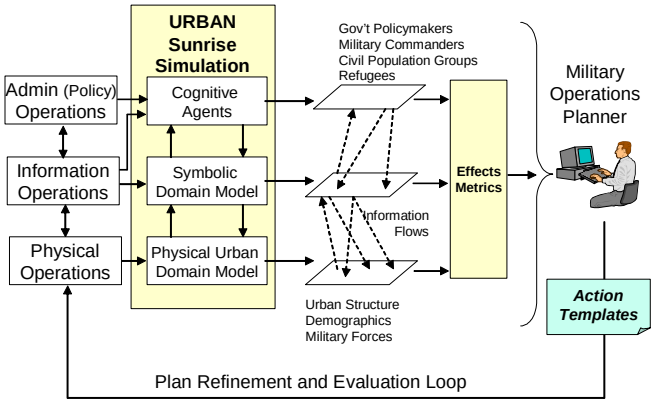
Ops Phase: Analysis of Effects Based Ops

- Operations simulation
- User selects action templates
  - Admin Ops
  - Military Ops
    - Info Ops
    - Physical Ops
- Action Options
  - Target
  - Action, Intensity, Duration
  - Time sequence of application
- User reviews effects and interactions



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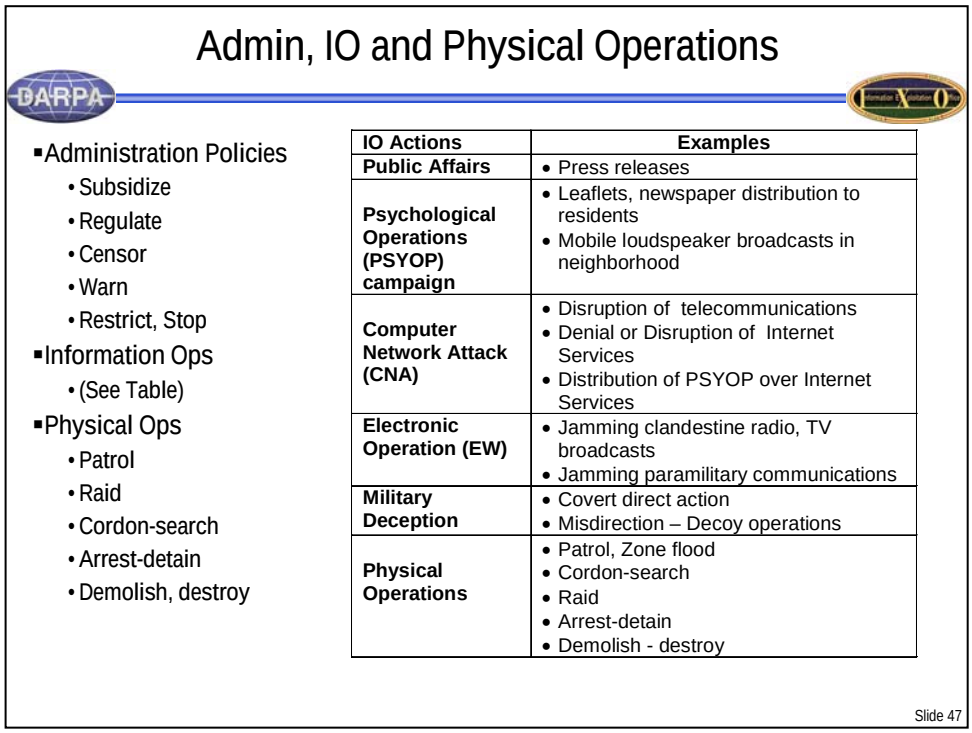


Three categories of actions (or course of action, or Blue policies) may be considered to influence the urban populations (and embedded opposition groups or terrorists).

The first category is administration policies adopted by the Civil Affairs (or occupying administration) to subsidize, regulate (by laws), censor (control information content), warn, restrict, or otherwise stop activities to achieve administrative goals (usually security goals).

The second category includes Information Operations (IO) that are enumerated in the table in the chart above. These operations are integrated across the spectrum of available IO methods described in Joint Publication 3-13 "Joint Doctrine for Information Operations".[14]

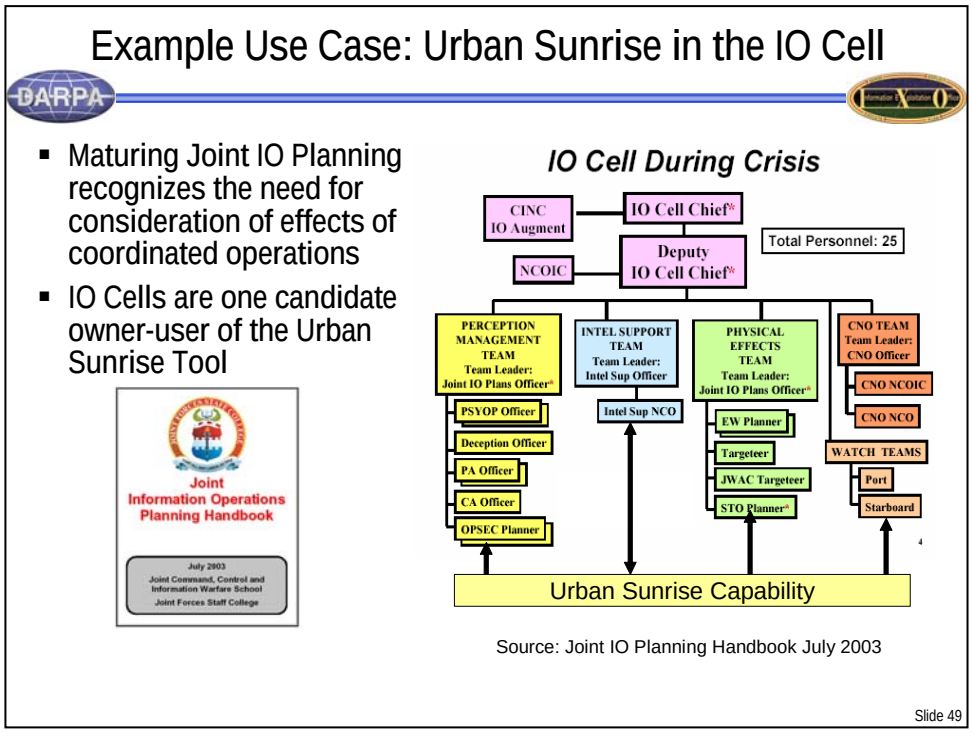
The third category includes physical security operations taken by military and police forces in support of the administration security goals. Typical operations (in increasing degree of aggressiveness) include: patrols, raids to surgically capture suspects and materiel, cordon-search, arrest-detain groups of suspected opposition, and demolish or destroy physical property used by opposition groups.

[14] JP 3-13 Joint Doctrine for Information Operations, JCS, 9 October 1998

2.3. Example Use Case

We consider in this section a representative use case to illustrate how Urban Sunrise capabilities might be used in a future operational application. The U.S. Joint IO Planning Handbook recognizes the need for consideration of effects of coordinated operations, and this use case illustrates how the Urban Sunrise capability will support a typical IO Cell (below).[15]

(It is important to recognize that this is a single use case; the IO cell is but one of many candidate owners-users of the Urban Sunrise capability.)

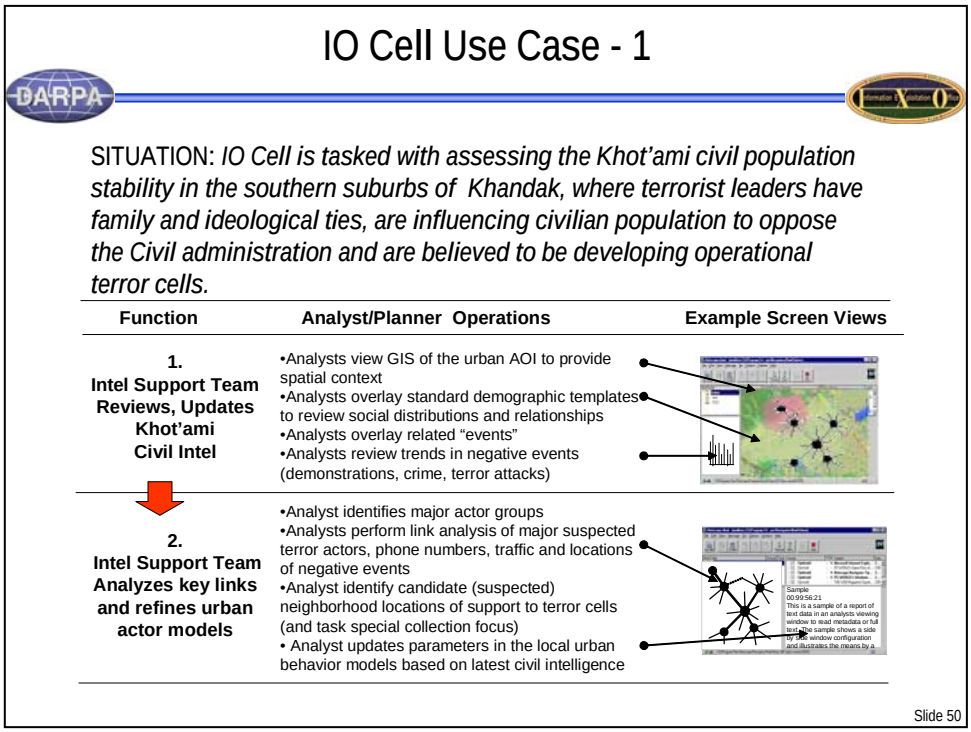


Consider, in the next several pages, the following situation to demonstrate one scenario of an Urban Sunrise operation:

SITUATION: A Division-level IO Cell is tasked with assessing the Khot'ami civil population stability in the southern suburbs of Khandak, where terrorist leaders have family and ideological ties, and are influencing civilian populations to oppose the Civil administration. These oppositions groups are believed to be developing operational terror cells.

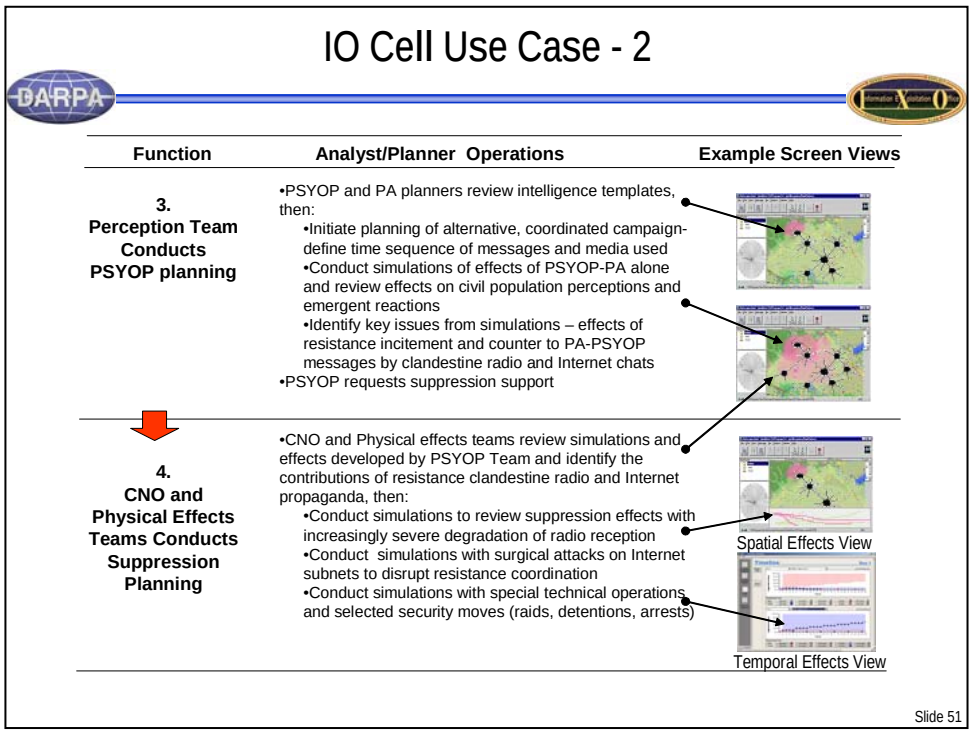
The following pages illustrate the activities of the IO Cell teams on the organization chart, above, defined in the Joint IO Planning Handbook.

[15] Joint Information Operations Planning Handbook, Joint Command and Control and Information Warfare School, Joint Forces Staff College, July 2003.



Step 1 Intel Support team Updates Civil Intelligence - Intelligence analysts view the GIS of the urban AOI to provide spatial context, then overlay standard demographic templates to review social distributions and relationships. The analysts also overlay related "events" in the knowledge base. The analysts review trends in negative events (demonstrations, crime, terror attacks) in the respective neighborhoods.

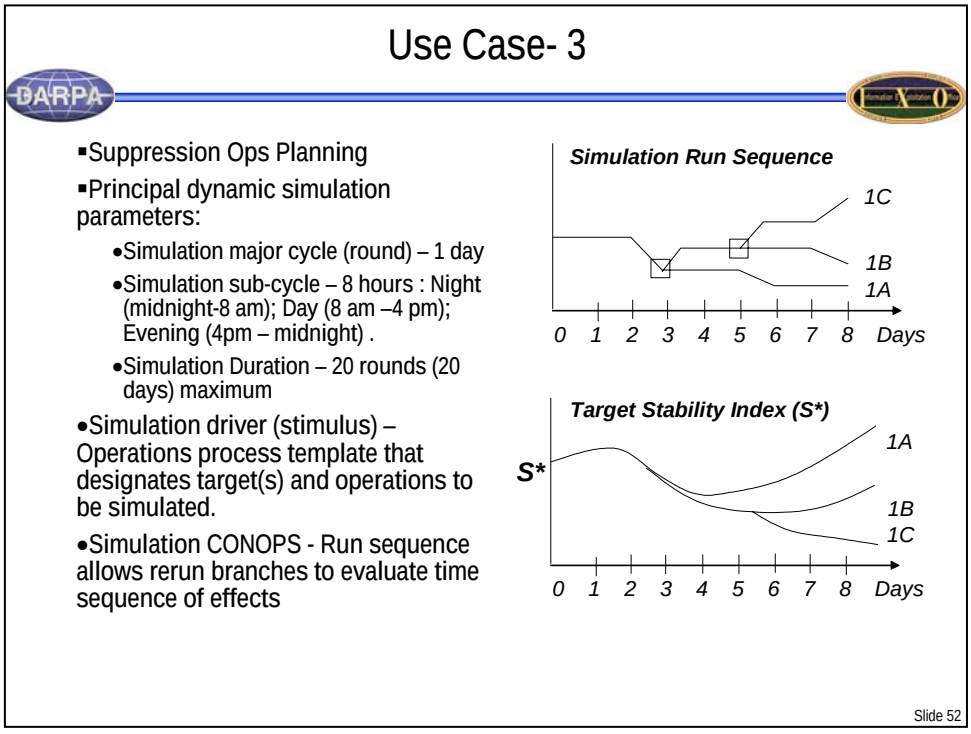
Step 2 Intel Support team Analyzes Links, Updates Actors – The analysts identify the major actor groups in the troubled area, and perform link analysis of major suspected terror actors, phone numbers, traffic and locations of negative events. The analysts identify candidate (suspected) neighborhood locations of support to terror cells, and task special collection focus. The analyst updates parameters in the local urban behavior models based on latest civil intelligence. In areas where there are gaps in intelligence special collections may be requested.



Step 3 Perception team conducts PSYOP Planning – PSYOP and Public Affairs (PA) planners review intelligence templates, then initiate planning of alternative, coordinated campaign. They define the themes, media, messages and time sequence of messages. The team then uses the EBO Simulation to conduct simulations of effects of PSYOP-PA alone and review effects on civil population perceptions and emergent reactions. The team identifies the key issues from simulations – the effects of resistance incitement and counter responses to the PA-PSYOP messages by clandestine radio and Internet chats.

As a result of these simulations, PSYOP recognizes the threats to the PSYOP campaign and requests suppression support from the CNO and physical effects Team.

Step 4 CNO and Physical Effects Teams conduct Planning - The CNO and Physical Effects teams review the simulations and effects developed by Perception Team and identify the contributions of resistance clandestine radio and Internet propaganda. Based on these results, the team conducts simulations to review the effects of suppression of the opposition's clandestine radio and Internet actions with increasingly severe degradation of radio reception and Internet access. First the team conducts simulations with surgical attacks on Internet subnets to disrupt resistance coordination, then they conduct simulations with special technical operations and selected security moves (raids, detentions, arrests).

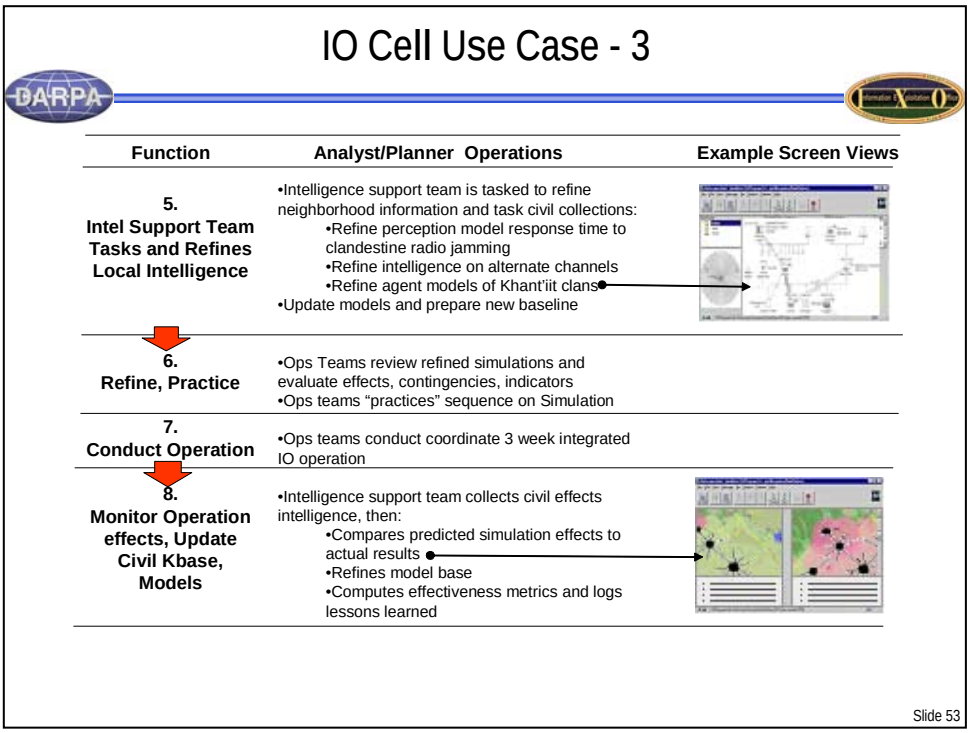


Step 4 (continued) Simulation Sequence - The sequence of simulation runs by the planning teams (above) illustrates the functions of suppression operations planning. The urban Sunrise EBO simulation is set to the following nominal dynamic simulation parameters:

Simulation major cycle (round) – 1 day
Simulation sub-cycle – 8 hours : Night (midnight-8 am); Day (8 am –4 pm); Evening (4pm – midnight) .
Simulation Duration – 20 rounds (20 days) maximum

The simulation driver (stimulus) is the operations process template that designates the civil population target(s) and the operations to be simulated. The Perception, CNO and Physical effects teams first applied the PSYOP campaign (1A) that initially increased the stability index (S*), but then destabilized again on days 5-8 (due to opposition counters by clandestine radio and Internet). Next, the clandestine radio jamming was applied (1B) to result in better stability (S*), but the Internet counters brought more instability in days 7-8. Finally, Internet CNO attacks were applied to mitigate the opposition access (1C) and the desired effect is continuing stability (S*) through day 9.

This sequence illustrates how the run sequence allows the users to rerun branches to evaluate time sequence of effects of multiple combinations of operations.



Step 5 Refinement of the Planned Operation – The intelligence support team is tasked to refine neighborhood information and task civil collections to achieve the highest accuracy possible for the planned combined operations. The collected data is used to:

Refine the perception model response time to clandestine radio jamming
Refine the intelligence on alternate channels
Refine the agent models of Khant'iit clans
Update the models and prepare new baseline

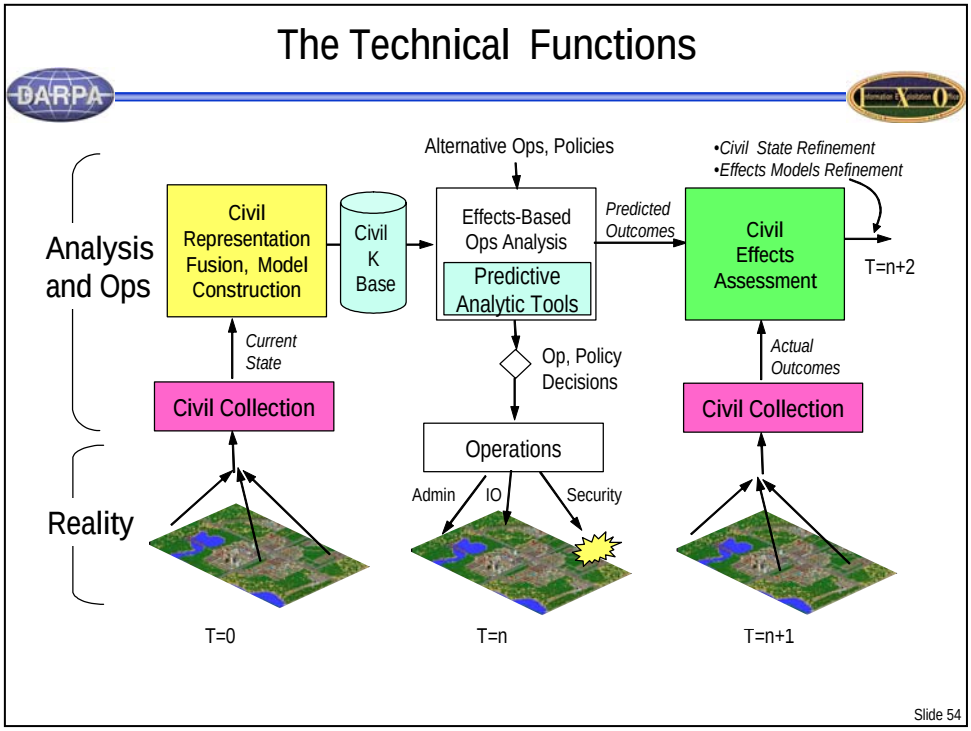
Step 6 Refine and Practice - Ops Teams review refined simulations and evaluate effects, contingencies, indicators. The Ops teams conduct "practice" sequences on the simulation to prepare for the operation

Step 7 Operations – the Ops teams conduct coordinated 3 week integrated IO operation; Intelligence collects data on the responses and consequences.

Step 8 Monitor Operations – The intelligence support team collects civil effects intelligence throughout and after the operation, then compares predicted simulation effects to actual results and refines the EBO model base. The team also computes effectiveness metrics and logs lessons learned.

2.4. The Technical Functions

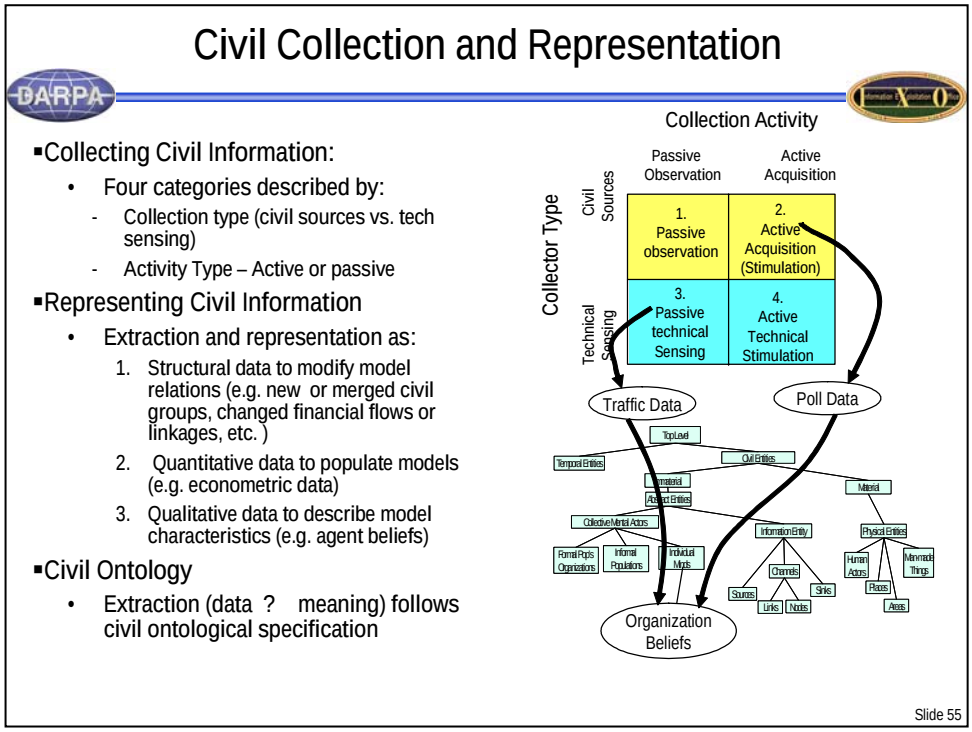
In this section, the operational and functional requirements for Urban Sunrise are introduced before discussing the recommended technical approach and supporting technologies.



The functional operations needed to implement URBAN SUNRISE (above) include several phases of activity:

7. Foreign Civil Collection – Civil information is collected from multiple sources
8. Foreign Civil Intelligence Representation and Fusion – Civil information must be used to represent actor-organizations, the flows of influencing information and constraining urban structures. The civil data fusion process must correlate and combine civil sources (e.g. text reports, media, polls, etc.) and new technical sensing sources into parameters that update simulations models of civil populations, their governments, and the information and physical infrastructure environment within which they live and act.
9. Civil Knowledgebase – The accumulated information forms a dynamic knowledgebase of civil intelligence for 1) direct query and analysis by intelligence analysts, and 2) translation into model data for EBO simulation.
10. Effects Based Ops Analysis – Urban simulation tools allow predictive and exploratory analysis of the effects of integrated operations on the mix of civil populations and belligerent organizations.

11. Operations – Integrated operations are carried out on the basis of more comprehensive understanding of the *potential* interactions of actors in the complex environment.
12. Civil effects Assessment – URBAN SUNRISE must include the capability to assess predicted and actual effects, and to refine effects models on the basis of those assessments.

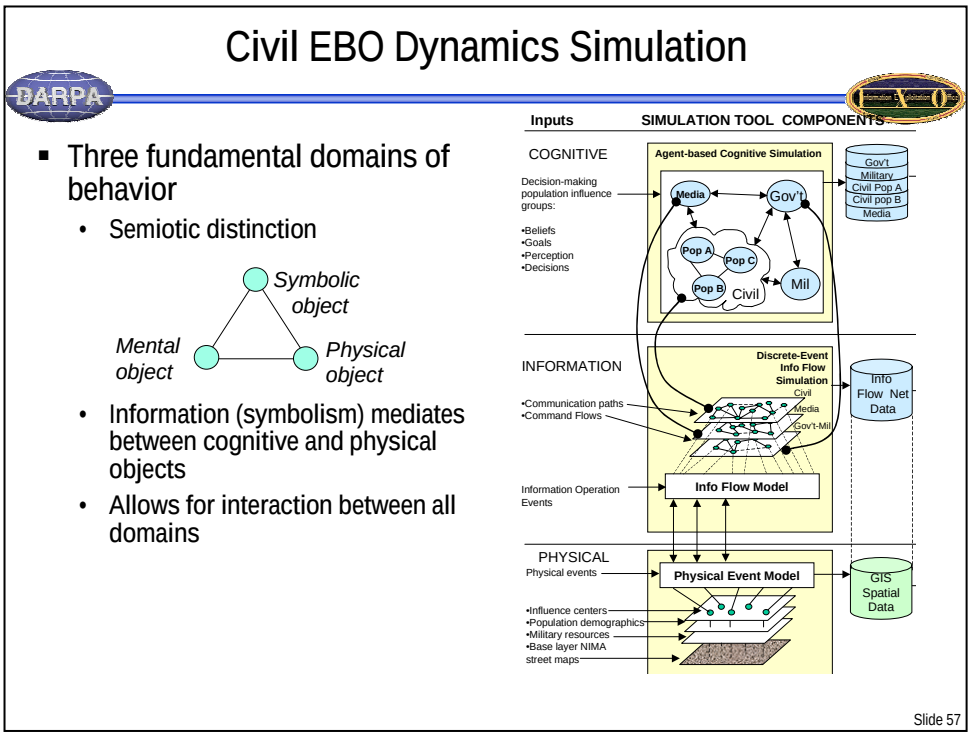


Civil Information must be first collected; this study has identified four categories of civil information described by two dimensions: 1) the collection type (civil sources vs. tech sensing) and 2) the type of collection activity (passive observation of subjects and processes or active stimulation of the sources).

Civil Information must also be represented in a number of ways to provide structured information for EBO models and both structured and unstructured (natural language) information for human analysts. The civil information must be extracted and represented as:

- Structural data to modify model relations (e.g. new or merged civil groups, changed financial flows or linkages, etc.)
- Quantitative data to populate models (e.g. econometric data)
- Qualitative data to describe model characteristics (e.g. agent beliefs)

Extracted and represented information must then be organized following a computational Civil Ontology to allow automated reasoning and automatic population of the EBO simulations.

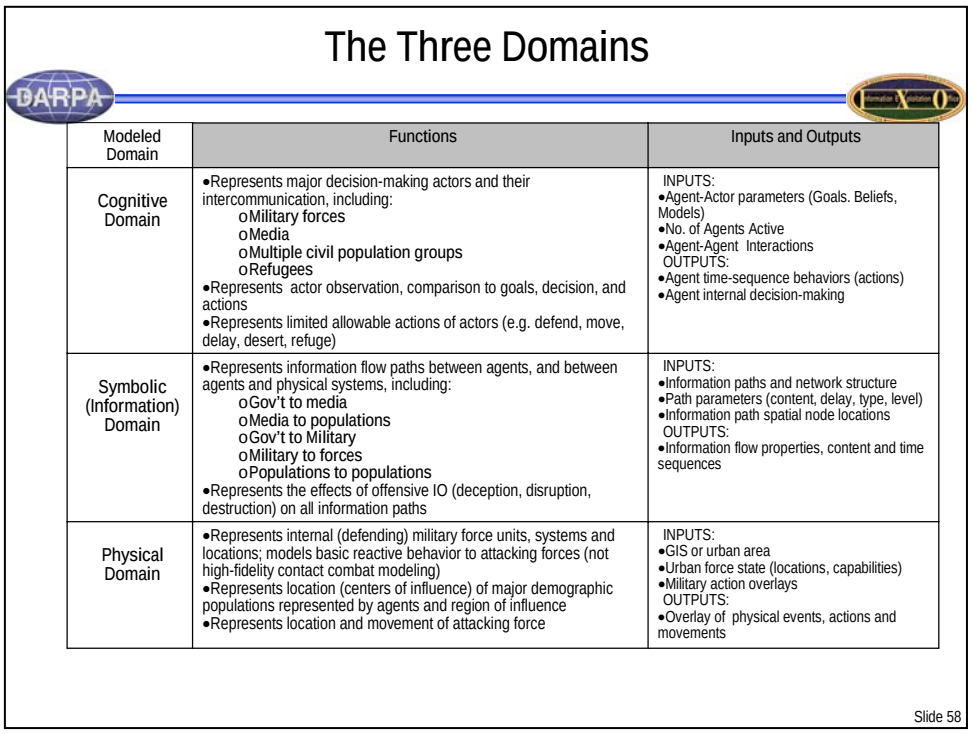


The functional architecture of the Civil EBO Dynamics simulation is characterized by three distinct domains of modeled interconnected behavior, each of which is described in the following paragraphs. The functions performed in each modeled domain are summarized in the table on the next chart. We propose a complex adaptive simulation to understand the effects of non-linear interactions in the highly interactive urban environment, where traditional analytic techniques and statistical analysis cannot cope. The non-linearity of such problems prohibits aggregate behavior prediction by methods of summation or averaging. The analytic simulation tool is characterized by the following:

- Agent-based discrete-time simulation is used to create a high level of reasoning and interaction among decision-making actors (the agents) and a virtual world model of the symbolic and physical realms to create complex adaptive system (CAS) behavior. The agents represent decision-makers and population groups that interact with the virtual world, seeking to achieve goals by selective world-controls and adaptation.
- Cognitive agents are selected to provide a high level of rational human-like reasoning to represent population groups or leadership decision-makers. (This is in contrast with the use of large numbers of simple rule-based agents as in the popular SWARM simulations.) We have chosen Soar agents that represent cognition as a problem-solving effort by applying operators in service of achieving goals. All long-term knowledge is uniformly represented by production rules that can be organized into operators. As well as an agent architecture, Soar is a candidate unified theory of human cognition, as defined by Newell.[16]

[16] Newell, A., *Unified Theories of Cognition*. Cambridge, MA, 1990.

- Discrete-time Differential Equations model the information flows of the symbolic layer and the movement of physical entities (military units, refugees, physical resources, etc.) across the urban terrain.



The Three Domains

Modeled Domain	Functions	Inputs and Outputs
Cognitive Domain	•Represents major decision-making actors and their intercommunication, including: oMilitary forces oMedia oMultiple civil population groups oRefugees •Represents actor observation, comparison to goals, decision, and actions •Represents limited allowable actions of actors (e.g. defend, move, delay, desert, refuge)	INPUTS: •Agent-Actor parameters (Goals. Beliefs, Models) •No. of Agents Active •Agent-Agent Interactions OUTPUTS: •Agent time-sequence behaviors (actions) •Agent internal decision-making
Symbolic (Information) Domain	•Represents information flow paths between agents, and between agents and physical systems, including: oGov't to media oMedia to populations oGov't to Military oMilitary to forces oPopulations to populations •Represents the effects of offensive IO (deception, disruption, destruction) on all information paths	INPUTS: •Information paths and network structure •Path parameters (content, delay, type, level) •Information path spatial node locations OUTPUTS: •Information flow properties, content and time sequences
Physical Domain	•Represents internal (defending) military force units, systems and locations; models basic reactive behavior to attacking forces (not high-fidelity contact combat modeling) •Represents location (centers of influence) of major demographic populations represented by agents and region of influence •Represents location and movement of attacking force	INPUTS: •GIS or urban area •Urban force state (locations, capabilities) •Military action overlays OUTPUTS: •Overlay of physical events, actions and movements

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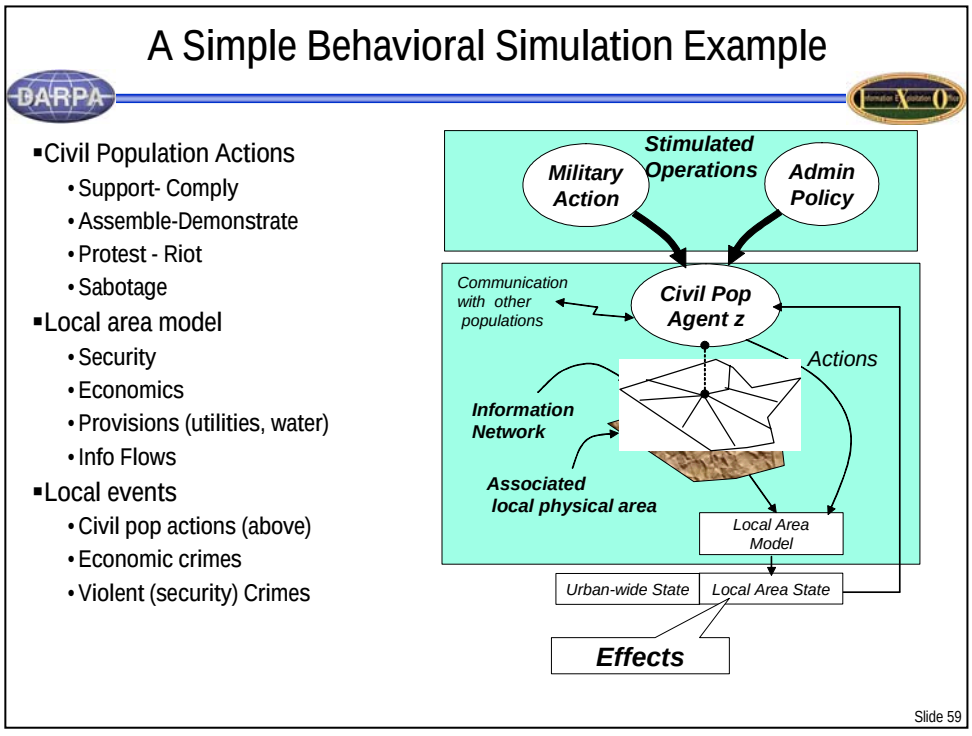
Cognitive Domain Model – Key human actor groups are represented by Soar cognitive agents; each agent represents the group behavior of key urban influences (the government policy-making leadership, military leadership, population groups, refugee groups, etc.) the agent-actors represent the aggregate decision-making behavior of these influences. The agents are characterized by:

- Prior Beliefs – Knowledge about the virtual urban world environment in which the agent resides and the causes and effects of potential actions.
- Goals – Qualitative or quantitative objectives (in the world) that are sought by the agent.
- Perceptions – Knowledge about the current urban situation as perceived by the agent and the effects of that state on agent goals.
- Assessment and Planning – Processes that compare current situations to goals to 1) detect threats to goal achievement and 2) detect opportunities to act toward goal achievement. In either case, the agent develops courses of action (plans) to move toward goals achievement and away from failure.
- Judgment – A process of assessing and selecting the "best" plans from among alternatives and making the "decision" to choose.
- Action – Ability to make changes in the virtual urban world (e.g. sending information, changing allegiances, moving locations, applying resources, influences or physical force).

Symbolic (Information) Domain Model - The symbolic domain represents the flow of information among actors (and the media and military C2 systems) and the capability for attacking forces to apply information operations (IO) to insert information, disrupt the flow of information, or destroy links. The domain includes a representation of the spatial locations of physical nodes, as appropriate for overlay on the urban map.

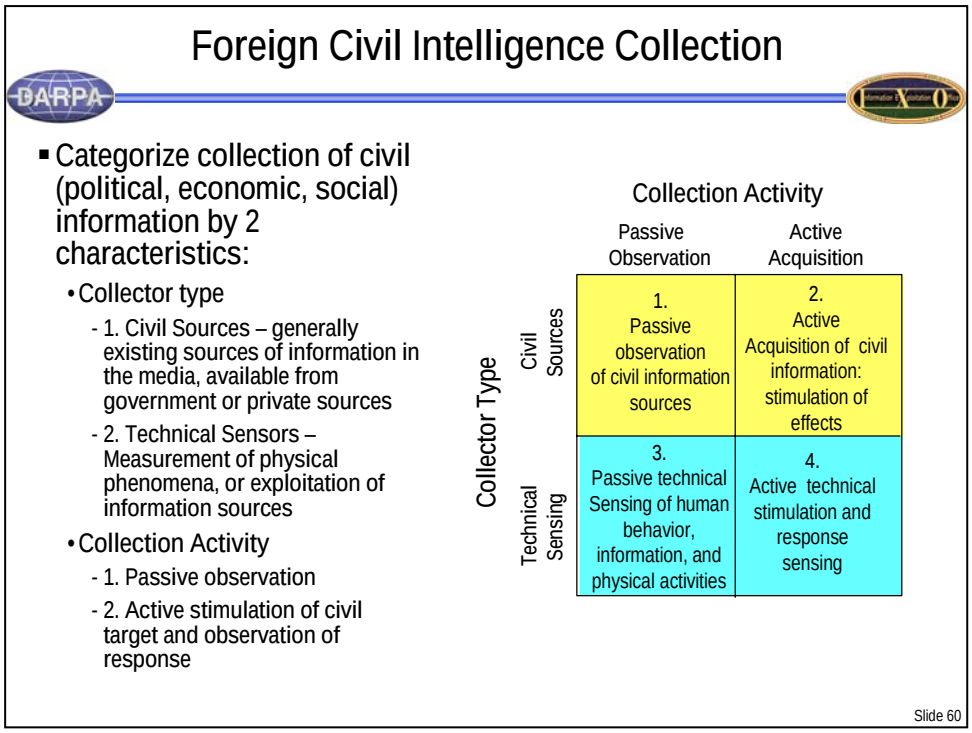
Physical Domain Model – The physical model is a basic urban map with a low resolution grid to place the location of: physical forces, demographics, influence centers, information nodes and flows, and other relevant physical entities and events. This layer is based on simple time-dynamic equations that are mapped onto a commercial urban map of the chosen foreign urban area.



In a simple behavioral simulation example, a time- series sequences of attacker operations (both physical and information ops) can be evaluated by inputting the attacker's actions in to the virtual information and physical domains as the simulation is run. The interactions, decision-making and responses of the urban defending military, civil populations and government leadership can be observed as these inputs are sequentially applied. The effects in all three domains can be observed, although the focus of this research is on the cognitive effects on the agents' decisions. Each individual agent is associated with information flows (media, command, communications, finances, etc.), a spatial area of existence and influence (e.g. population centers and boundaries), and inputs (actions applied by blue administration and opposition) and outputs (actions and effects of decisions).

2.5. Foreign Civil Intelligence Collection

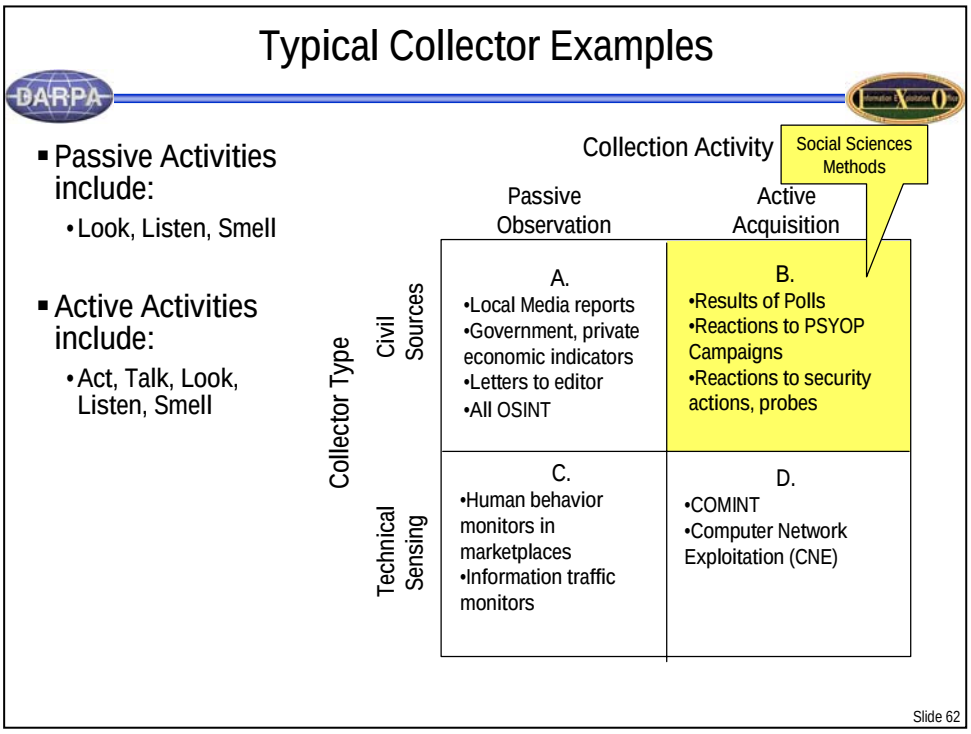
Civil Information must be first collected; this study has identified four categories of civil information described by two dimensions: 1) the collection type (civil sources vs. tech sensing) and 2) the type of collection activity (passive observation of subjects and processes or active stimulation of the sources).



The chart above categorizes the collection of civil (political, economic, social) information by 2 characteristics, collector type and activity:

- Two Collector types
  - 1. Civil Sources – generally existing sources of information in the media, available from government or private sources
  - 2. Technical Sensors – Measurement of physical phenomena, or exploitation of information sources
- Two Collection Activity
  - 1. Passive observation
  - 2. Active stimulation of civil target and observation of response

Currently, civil information collection is conducted by military collection of civil information is secondary to combat intelligence; the sources are generally SITREPS and open sources. Collection must deal with error, distortion, contradiction and uncertainty. Government sources and channels are subject to misinformation, political distortion, while private sources (e.g. economic data) are subject to error, incompleteness, and uncertainty. DIA's Modernized Intelligence Data Base (MIDB) has a limited capability to store civil information, but is currently not suitable or sufficient for Urban Sunrise.



Examples of the four categories of collection items are illustrated in the chart above.

- A. Passive civil sources – include passive collection of relevant civil sources (e.g. local media reports, Government, private economic indicators, Letters to editor in local media, and all OSINT
- B. Actively Acquired civil sources – include the results of stimulated civil activity (e.g. results of polls, reactions to PSYOP Campaigns, reactions to security actions and probes).
- C. Passive technical sources - include the passive collection of technical sensor data that can be used to infer human behavior (e.g. Human behavior monitors in marketplaces, information traffic monitors, etc.)
- D. Actively Acquired technical sources – include those special collections by technical sensors following special stimulation of target populations or individuals (e.g. COMINT or Computer Network Exploitation (CNE) following special PSYOP stimulation activities).

The tables in the charts on the following pages enumerate representative sources for each of the four categories; the charts indicate which model factors are derived from each of the collected elements.

A. Passive Observation

Civil Information	Example Collection Sources	Model Factors Derived		
		Physical	Symbolic	Cognitive
1. Physical Setting	Government maps, charts	Locations of entities, channels and coverage		
	Organization maps, charts			
	Telephone, commerce address books			
	Gazeteers,Resource directories			
2. Political	Media sources (radio, TV, reports etc.)	Location of facilities, actors Boundaries of influence	Means of communication, channels and targets	Pol Organization goals, beliefs, perceptions, capable actions
	Organizational press releases, Internet sites			
	Tasked HUMINT Observations			
	Event reporting – with attribution			
3. Social-Cultural	Health, hospital statistics	Health, welfare, financial, ideological demographics	Population information sources, networks, sinks	Population group goals, beliefs, perceptions, capable actions
	Police reports, media crime reports			
	Census and anthropometric data sources			
	Traffic (foot, auto, rail, air)			
	Letters to officials, demonstrations			
4. Economic	Markets internal and external	Economic demographics	Economic model resources, activity, and performance parameters	Economic actor properties
	Trade organization information			
	Business organization reports			
	Business traffic, production – physical activity			
5. Media	Print media (newspapers, magazines)	Locations of sources, coverage of sinks	Communication network logical structure	
	Broadcast media (radio, TV)			
	Internet			
6. External	U.N sources; NGO official information reports	Locations	Information and financial exchange nets	NGO goals, beliefs, perceptions, capable actions
	Third party country reports			

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B. Active Observation

Civil Information	Example Collection Sources	Model Factors Derived		
		Physical	Symbolic	Cognitive
1. Physical Setting	Scouting reports, observations	Locations of entities, channels and coverage, building materials, samples		
	Queries to local populace, business, government			
	HUMINT			
	Establish business or residence			
2. Political	Reactions and decisions to Media stories, fabricated or real (radio, TV, reports etc.)	Location of facilities, actors Boundaries of influence	Means of communication, channels and targets	Pol Organization goals, beliefs, perceptions, capable actions
	Scout out and monitor key actors			
	Tasked HUMINT reporting			
	Polls and Surveys			
3. Social-Cultural	Population, building counting by locations	Health, welfare, financial, ideological demographics	Population information sources, networks, sinks	Population group goals, beliefs, perceptions, capable actions
	Rallys, polls, surveys, demonstrations			
	Transaction processing info, purchases, sales			
	HUMINT and local reports			
	Attend local events, markets, set up residence			
4. Economic	Make purchases on Markets internal and external, trade local and international	Economic demographics	Economic model resources, activity, and performance parameters	Economic actor properties
	Monitor banks, markets, shops, warehouses, prices, sales, trade			
	Set up a business			
	Investigate or setup underground and black markets			
5. Media	Newspaper ads, leaflets, post signs	Locations of sources, coverage of sinks	Communication network logical structure	
	TV, radio ads			
	Internet, telephone, IM ads or polls			
6. External	U.N or international meetings, reactions to international cable, TV, internet	Locations	Information and financial exchange nets	NGO goals, beliefs, perceptions, capable actions
	Results of trades, embargos, imports, exports			

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C. Passive Technical Sensing

Civil Information	Example Collection Sources	Model Factors Derived		
		Physical	Symbolic	Cognitive
1. Physical Setting	Mounted cameras, FLIR	Locations of entities, channels and coverage, supply locations	Traffic flow and patterns. Info flow and connections	
	Phone taps, electrical or network monitoring			
	Scanning radio, TV freqs			
	Unattended Ground Sensors			
2. Political	Monitor Internet, wireless traffic and locations	Location of facilities, actors Boundaries of influence	Means of communication, channels and targets	Pol Organization goals, beliefs, perceptions, capable actions
	Sensors and cameras on actors			
	Record facial expressions, voice tones			
	Monitor populations, organizations in key locations			
3. Social-Cultural	UAVs, Satellites to count populations	Health, welfare, financial, ideological demographics	Population information sources, networks, sinks	Population group goals, beliefs, perceptions, capable actions
	Monitor Police radios, media (TV, radio, wireless, internet) reports			
	Set up cameras and monitor people, traffic, buildings, markets, borders			
	Monitor internet, wireless, phone traffic			
	GIS, database data and records			
4. Economic	Cameras to record banks, shops, businesses	Economic demographics	Economic model resources, activity, and performance parameters	Economic actor properties
	Monitor stock, internet, stores digital transactions			
	Wiretaps, radio scanning, satellites			
	Sensors to monitor peoples transactions, living conditions, activities, jobs			
5. Media	Cameras to monitor print media distributions	Locations of sources, coverage of sinks	Communication network logical structure	
	Monitor and scan radio, TV wireless spectrum			
	Internet tracking and monitoring			
6. External	Internet, GIS and other databases	Locations	Information and financial exchange nets	NGO goals, beliefs, perceptions, capable actions
	Monitor embassies, internal and external			

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D. Active Technical Sensing

Civil Information	Example Collection Sources	Model Factors Derived		
		Physical	Symbolic	Cognitive
1. Physical Setting	Cameras, LADAR, Sound, UAV, UGV, Satellite	Locations of entities, channels and coverage, material, traffic, Supply locations		
	Database, Internet lookups, Automated Surveys			
	Scanning Radio and TV, wireless, phone, electrical			
	Unattended and Mobile Ground Sensors			
2. Political	Recoding of physical, emotional, behavior of populations from stimulus reports or actions	Location of facilities, actors Boundaries of influence	Means of communication, channels and targets	Pol Organization goals, beliefs, perceptions, capable actions
	Computer exploitation and hacking			
	Tag along or implanted sensors			
	Unattended and Mobile Ground Sensors			
3. Social-Cultural	UGS to monitor and track populations, buildings, jobs and activities	Health, welfare, financial, ideological demographics	Population information sources, networks, sinks	Population group goals, beliefs, perceptions, capable actions
	Stage riots injuries, crime in monitored locations			
	Wireless, radio, TV ads, SPAM			
	Tag money and goods to track			
	Set up a business, club, restaurant			
4. Economic	Create or destroy jobs, business to track activities	Economic demographics	Economic model resources, activity, and performance parameters	Economic actor properties
	Perform stock trades, monitor activities			
	Tags to track goods, trade, production			
	Active Media reports or Ads			
5. Media	Tag and monitor media, distributions, reporters	Locations of sources, coverage of sinks	Communication network logical structure	
	Broadcast or transmit TV, radio signals			
	Internet hacking, wiretaps			
6. External	Trade, internet, phone, wireless jamming or embargos	Locations	Information and financial exchange nets	NGO goals, beliefs, perceptions, capable actions

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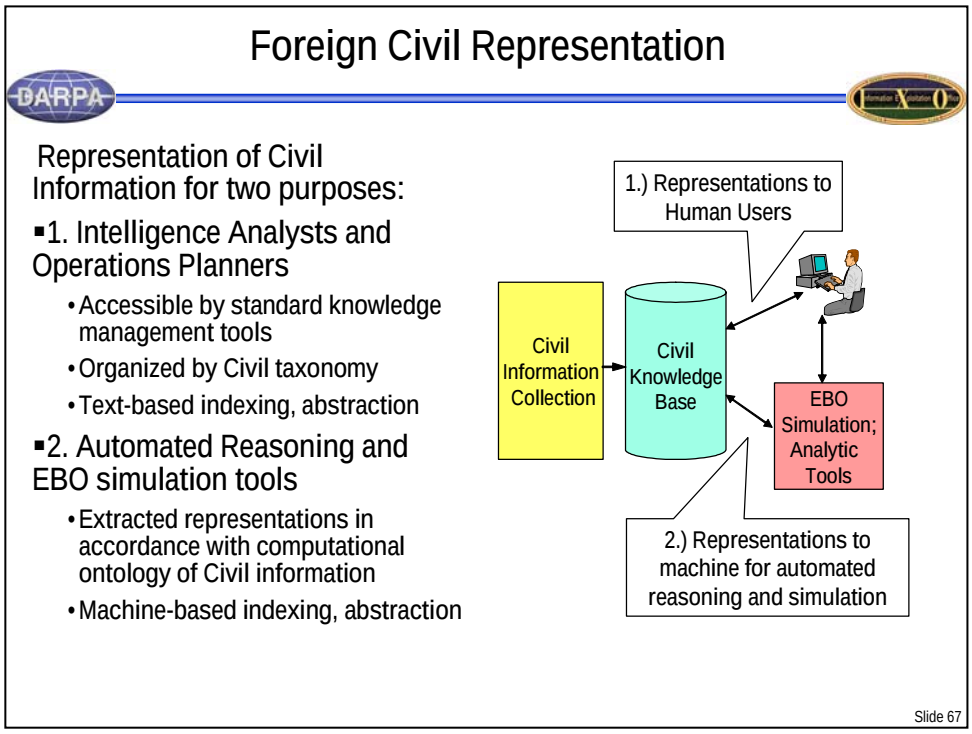
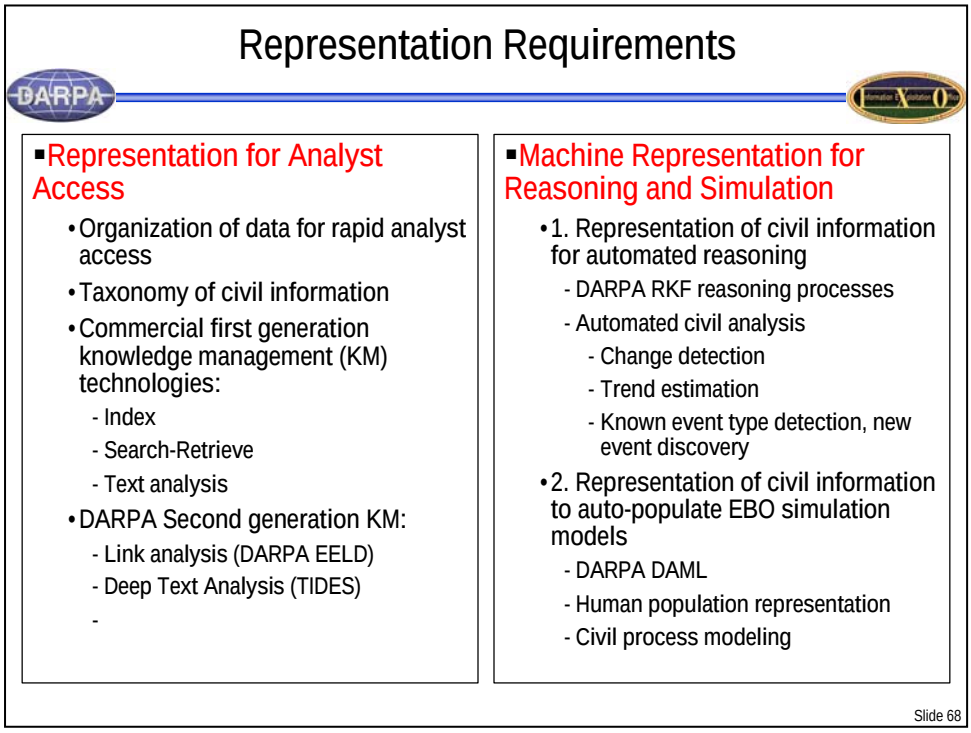
2.6. Foreign Civil Representation



Urban Sunrise requires that foreign civil information must be represented explicitly for two purposes.

First, the information must be represented in a manner readable by Intelligence Analysts and Operations Planners. Structured (forms) and unstructured text information on civil intelligence may be accessible by standard knowledge management tools; the information may be organized by the civil intelligence taxonomy introduced earlier. Current commercial knowledge management technology and advanced text-based indexing, abstraction, linking and summarization technologies developed by DRPA are appropriate for this representation capability.

Second, civil information must be represented by the ontology described earlier to support automated Reasoning and EBO simulation tools. The extracted information (derived from the diverse collection sources) is represented according to the computational ontology to permit machine-based indexing, abstraction, reasoning and automated population of the EBO simulations.



The two forms of representation are summarized above. Representation for human analyst access requires the information to be organized for rapid analyst access, following the taxonomy of civil information. Commercial first generation knowledge management (KM) technologies provide the capabilities for:

- Indexing by taxonomy
- Search-Retrieve
- Text analysis (abstraction, summarization)

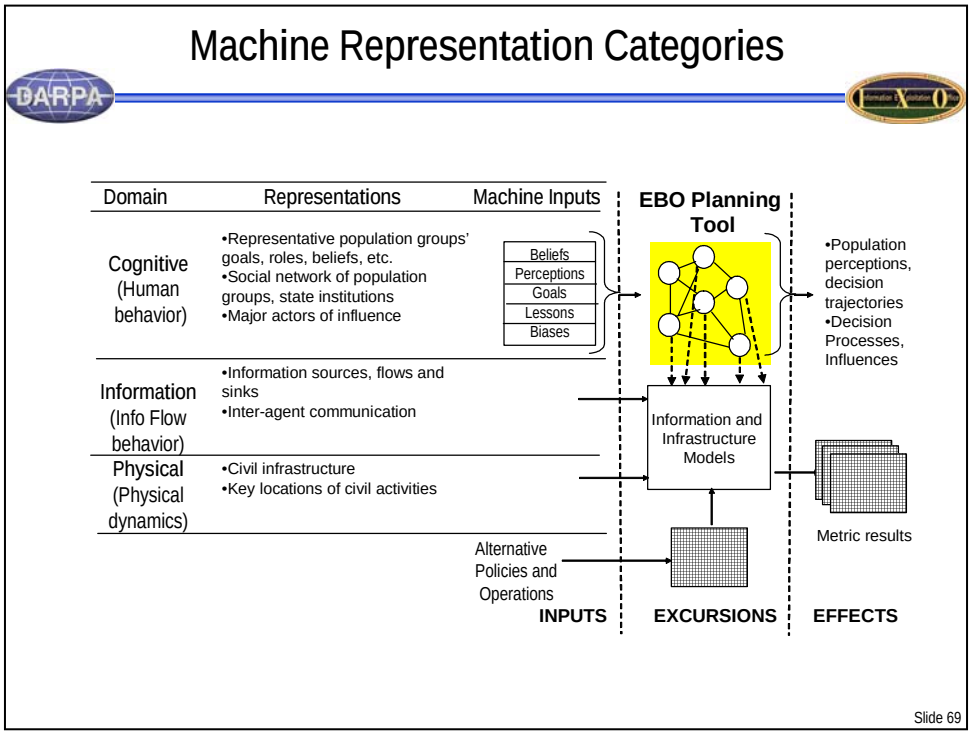
DARPA Second generation KM technologies add the capabilities for analysts to perform:

- Link analysis (DARPA EELD)
- Deep Text Analysis (TIDES)
-

Machine Representation represents civil information in a structured manner to support automated reasoning about the civil conditions, as demonstrated on the DARPA Rapid Knowledge Formation (RKF) and High Performance Knowledge Base (HPKB) programs. This capability will provide automated civil analysis for:

- Change detection
- Trend estimation
- Known event type detection, new event discovery

The machine representation also is required to auto-populate the EBO simulation models.

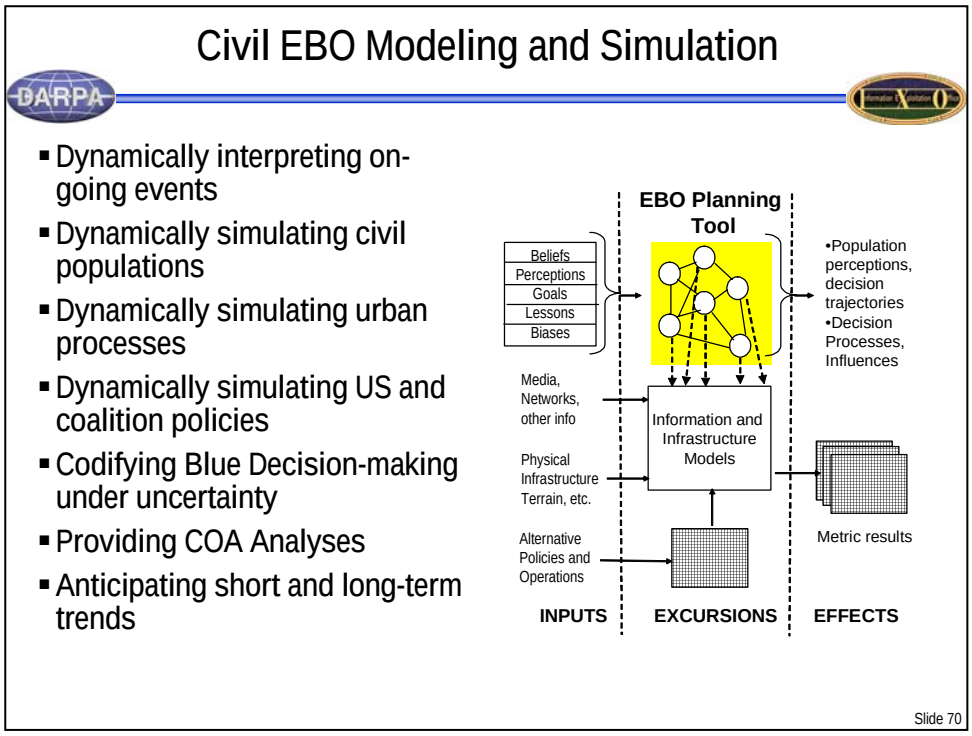


The three categories of collected information must be transformed into machine representations for populating the three domain EBO simulation. The chart above illustrates how the three categories of collected information provide inputs to the information and physical models in the simulation and then agent-actors that represent the collective human decision-making of civil populations.

The following sections describe the implementation and human behavior representation challenges posed by the EBO simulation.

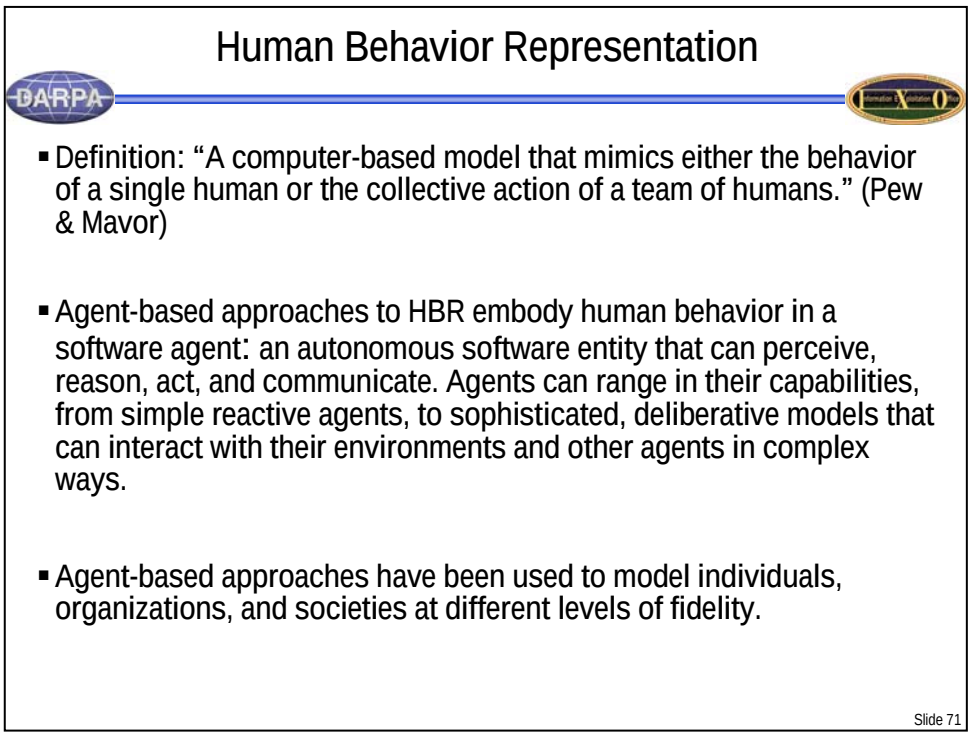
2.7. Foreign Civil EBO Modeling and Simulation

This section describes the key concepts in applying agent-based simulation to the task of representing human populations and evaluating the high dimensional output of the simulations.



The three domain simulation, once populated with current estimated state of the urban civil population, faces seven key challenges to provide understandable and useful results to provide practical support to military operations:

- Dynamically interpreting on-going events – Events observed by intelligence must accurately interpreted and translated into physical, information and cognitive states in the model.
- Dynamically simulating civil populations – The simulation must provide a faithful Human Behavior Representation (HBR) for aggregate population groups and continually simulate the population for current conditions and evaluate the accuracy of predicted behavior to actual events.
- Dynamically simulating urban processes –Similarly, the models of urban processes systems (information and physical) must be continually refined.
- Dynamically simulating US and coalition policies – The simulation must faithfully represent all crucial influences applied by the U.S. and coalition policies and course of action.
- Codifying Blue Decision-making under uncertainty –Blue (U.S. and coalition) decision making under uncertainty must be represented.
- Providing COA Analyses – Analyses of the effects of alternative policies or courses of action (COA's) must be considered.
- Anticipating short and long-term trends – Finally, the simulation must consider the effects of short and long-term trends in the social, political and economic environment.



Human Behavior Representation (HBR or alternatively described as Human Behavior Modeling, HBM) encompasses a wide range of methodologies, including individual and organizational behavior. One approach that has shown great promise is using software agents to represent human behavior. An agent is an autonomous software entity that can perceive, reason, act, and communicate (Huhns and Singh, 1998).[17] Agents can vary in complexity, depending on the goals of the modeler. The simplest agent simply reacts to the changes in its environment.

Alternately, a stronger view of agency says an agent is characterized by autonomy, social ability, reactivity, and proactivity (goal-directed behavior) (Wooldridge and Jennings (1995).[18] Agent-based human behavior representation has been used successfully in a wide range of applications, including intelligent computer generated forces for military simulation (Jones, et al, 1999)[19], anytime algorithms for plan generation (Sauter, et al, 2002)[20], models of social interaction

[17] Huhns, M. and Singh, M. (eds.) (1998) *Readings in Agents.* : Morgan Kaufman: San Francisco, CA.

[18] Wooldridge, M. and Jennings, N.R. (1995) Intelligent agents: Theory and practice. *Knowledge Engineering Review,* 10: 115-152.

[19] Jones, R. M., J. E. Laird, P. E. Nielsen, K. J. Coulter, P. G. Kenny and F. V. Koss (1999). "Automated Intelligent Pilots for Combat Flight Simulation." AI Magazine **20**(1): 27-42.

[20] Sauter, J., Matthews, R., Parunak, H.V.D., Brueckner, S. "Evolving adaptive pheromone path planning mechanisms." AAMAS 2002: 434-440.

(Prietula and Carley, 1999) [21] and cultural emergence in artificial societies (Axelrod, 1997).[22]

One subset of HBR, Agent-based modeling (ABM), describes a method for understanding complex, dynamic systems of behavior through computational simulation of software agents. Agent-Based Models are appropriate when there are no known mathematical (e.g., optimization) or equation-based solutions (e.g., systems dynamics, macroeconomic models) to explain a complex system. When the problem can be characterized in a decentralized manner (no centralized control), when there is some understanding of the local interactions between elements in the system, or when the system is non-linear in nature, ABMs may be used to understand the system. Given their inherent multi-agent nature, ABMs are a natural fit for modeling organizations and societies. [23]

Taxonomy of Approaches for HBR

APPROACH	CHARACTERISTICS	EXAMPLES
Influence Networks	Static network of relationships model relative influence of causal effects across networks; nodes are not autonomous agents	Bayesian Networks, Colored Petri Nets
Cellular Automata	Very simple agents that react to their local environment; characterized by emergent patterns of behaviors	Conway's Game of Life (Gardner, 1970)
Complex adaptive system of basic agents	Simple Behavioral agents that can interact with other agents and adapt to their environment. Focus on emergent behavior at a system level. Often includes evolutionary approaches.	SWARM (Langdon, et al, 1997) SugarScape (Epstein & Axtell, 1996)
Structured, Distributed Specialized Agents	Individual agent is designed to solve narrow problems; can solve more complex problems by working with other agents. Often used in e-commerce applications.	Aglets (Karjoth, 1997) JADE (Bellifemine, et al, 1999)
Socially Networked Cognitive Agents	General problem-solving platforms, useful when the individual agent must interact with other agents and environment in complex ways. Generally brings large amounts of knowledge to bear to solve problems, including beliefs, desires, and intentions, and multiple problem-solving strategies. Sometimes founded in *cognitive architectures.*	Soar (Laird, et al, 1987) ACT-R (Anderson and Lebiere, 1998) JACK (Howden, et al, 2001)

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Within the taxonomy of human behavior representation (HBR), there is a wide range of approaches and methodologies, each with its own advantages and disadvantages. One useful dimension to distinguish these approaches is the sophistication of the individual agents that compose the model. Some approaches

[21] Prietula, M. and Carley, K. (1999) "Exploring the Effects of Agent Trust and Benevolence in a Simulated Organizational Task," *Applied Artificial Intelligence*, 13(3): 321-338.
[22] Axelrod, R. (1997) The Complexity of Cooperation" Princeton University Press: Princeton, NJ.
[23] Pew, R., and Mavor, A. (eds) (1998). *Modeling Human and Organizational Behavior: Applications to Military Simulations.* Washington, DC: National Academy Press.

derive from the traditional artificial intelligence (AI) paradigm, where more attention is paid to the capabilities of the individual agent. These *Cognitive Agents* typically abide by the Wooldridge and Jennings definition of agency, and may have capabilities such as deliberation, planning, language understanding, and learning.

Other approaches derive from the Cellular Automata paradigm, in which an agent, called a *Behavioral Agent,* is defined by a few simple rules for its behavior and interactions with other agents. The primary focus in the Behavioral Agent approach is on the total system of agents and their interactions. A class of Behavioral Agent models, called Complex Adaptive Systems, focuses on the emergence of system-level behavior from interaction and adaptivity of simple agents. The table above offers a taxonomy of selected ABMs distinguished by levels of agent sophistication. [24]

[24] See, for example the following references:

[1] Bellifemine, F., Poggi, A., Rimassa, G. JADE – A FIPA-compliant agent framework Proceedings of PAAM'99, London, April 1999, pgs 97-108. http://jade.cselt.it/

[2] Bonabeau, E., Dorigo, M., and Theraulaz, G. (1999) *Swarm Intelligence: From Natural to Artificial Systems*. Oxford University Press: New York.

[3] Epstein, J. M. and Axtell, R. (1996) *Growing Artificial Societies - Social Science from the Bottom Up*. MIT Press: Cambridge, MA.

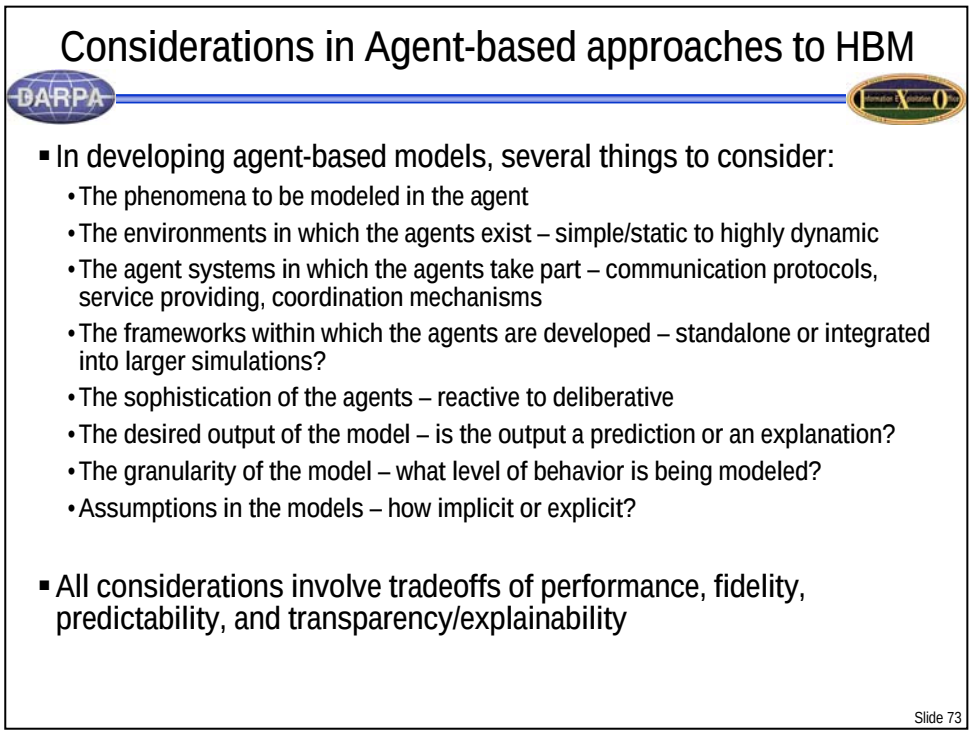
[4] Gardner, M. (1970) "The fantastic combinations of John Conway's new solitaire game 'life'." *Scientific American*: 223. October. pgs 120-123.

[5] Howden, N., Ronnquist, R., Hodgson, A., Lucas, A. (2001) JACK Intelligent Agents – Summary of an Agent Infrastructure. 5th International Conference on Autonomous Agents.

[6] Karjoth, G., Lange, D., Oshma, M. (1997), A Security Model for Aglets, IEEE Internet Computing, Vol. 1, No. 4, July/August .1997

[7] Laird, J. E., A. Newell and P. S. Rosenbloom (1987). "Soar: An architecture for general intelligence." *Artificial Intelligence* 33(3): 1-64.

[8] Langton, C., Burkhart, R., and Ropella, G. (1997) The Swarm Simulation System. http://www.swarm.org

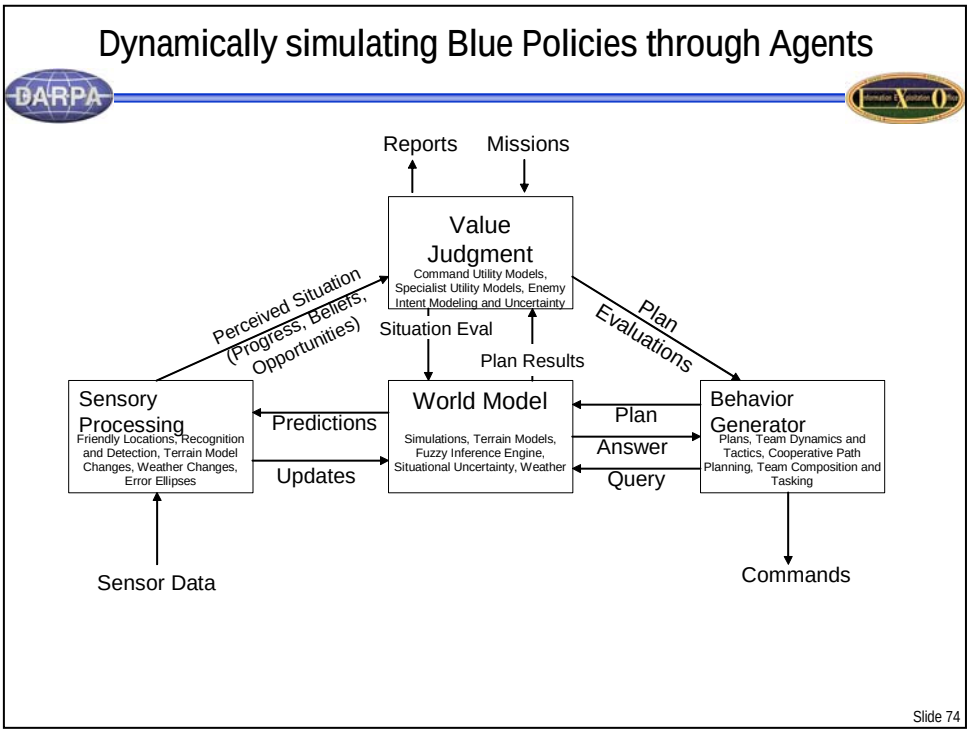


There are many practical and theoretical considerations in using ABMs for modeling complex systems. In comparing methodologies, one must consider the agents themselves, the multi-agent systems and environments in which they are placed, the frameworks within which they are developed, and the phenomena they are meant to model. All these considerations involve tradeoffs of performance, fidelity, and transparency. In looking at the individual agents, the level of agent sophistication must be matched to the system being modeled, the selected phenomena one wishes to model, and the desired fidelity with which to model the phenomena. Individual agents in the CAS paradigm are often quite simple to develop, but an explanation for the behavior generated by the system is not always transparent in the end: the task of explanation is often left to the modeler. Cognitive agents, with their required knowledge, are more time consuming to develop, but can be more explicit in the causal explanation of the model. Similarly, if there is a requirement in the model for high fidelity, complex decision-making in an individual agent, a CAS is probably not appropriate.

One consideration is the granularity of the agents themselves. In both Behavioral and Cognitive systems, agents typically represent individual decision-makers in a population. Group decision-making is demonstrated by having multiple agents interact to come to consensus. However, if certain assumptions can be made about the group (such as its homogeneity) or if the intra-group interactions are simply not important to the modeler, one can consider modeling a group of individual decision makers as a single agent with the “aggregate” characteristics of that group (that is, assign perceptions, beliefs, and goals to the group).

Another consideration in developing ABMs is in the desired output of the model. If the goal is to understand the dynamics of a complex system, its structure and processes, an emergent model may be very useful. If, instead, the goal is to use

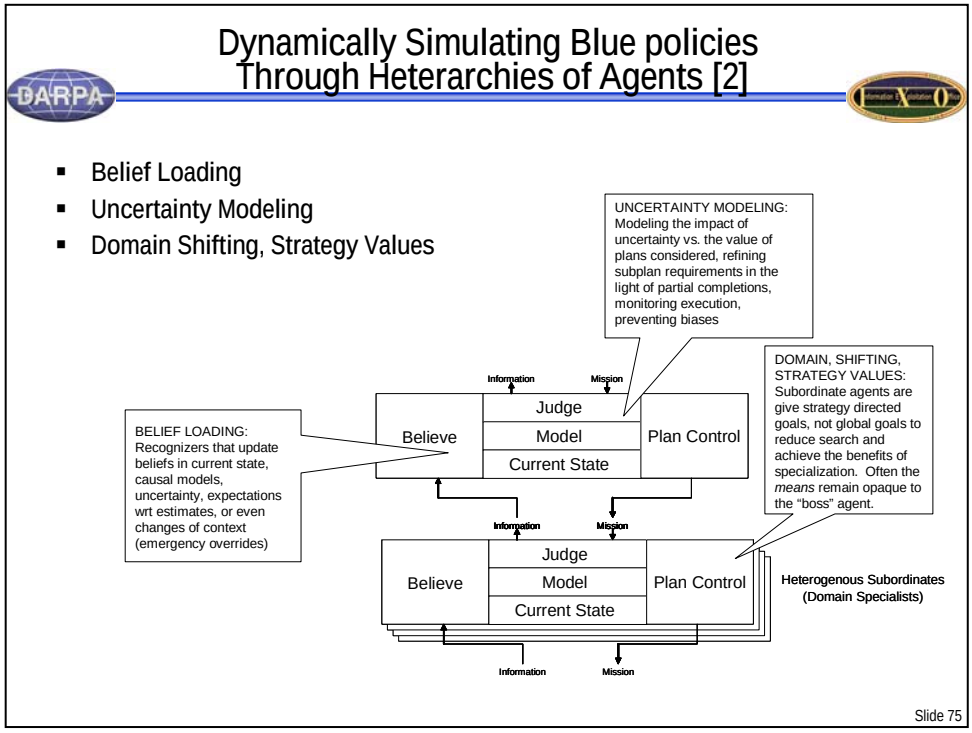
the model for predictive purposes, different choices may have to be made. Emergent properties of a model may help the modeler understand the system enough that predictions can be made; however, the model outputs are not necessarily predictions in and of themselves. Indeed, purely emergent models have difficulty representing or recreating specific real-world phenomena. Alternately, where causality at a system level is more explicitly present in the model, the model is more capable of producing explainable predictions.



The basic model for a simple agent is illustrated above, following the structure of an extension to the classic RCS-4 architecture. [25] The components and their functions include:

- Sensor processing – accepts sensor data to perceive the environment within which the agent is operating. The perceived situation is passed to the Value Judgment function.
- Value Judgment – Compares the current situation to goals (which are based in the agent's core values); the function evaluates the situation by consulting the world model to assess the implications of the current situation to future consequences (relative to goals) to determine both threats and opportunities. This function creates and evaluates alternative plans of action (policies) before selection to issue new behaviors to achieve the agent's goals.
- World Model – contains models of the agent' environment, providing predictions of the effects of potential plans.
- Behavior Generator – Implements the selected plans by issuing commands to influence the agent environment.

[25] Albus, J. S. (1992). RCS: A Reference Model Architecture for Intelligent Control. *IEEE Computing* 25(5):56-59.



The basic agent element (or, "conceptual automaton, or "cobot") presented on the prior page may be combined as shown above to create more sophisticated agent behaviors (e.g. the aggregate agent that represents a foreign civil population group), with each agent operating a designated level of problem abstraction. The network of agents implement the recursive function:

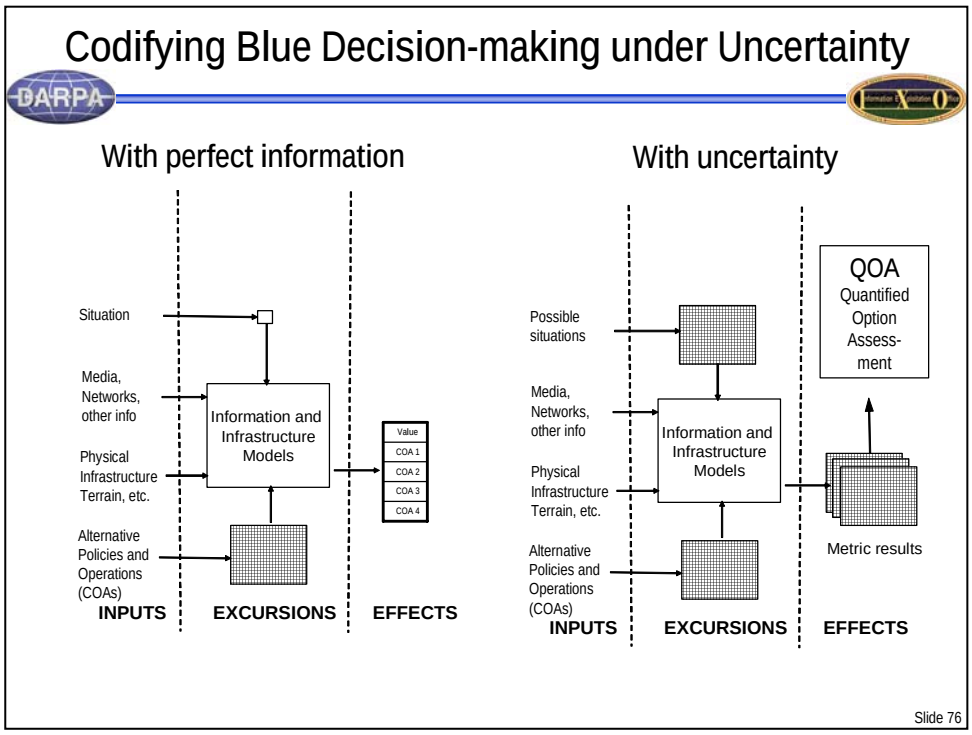
Value(*Bel*(Results(*Bel*(S_0),$Plan_i$,*Bel*($Situation_j$)), Goals, Uncertainty),

where the belief about current state, S_0, and the environment $(\text{current situation})_j$, affects the Plan. The resulting state vector, Results[], is judged according to our Goals and our estimate of Uncertainty. This two-stage function allows us to investigate deception and novel courses of action (the strategic value of surprise) when determining Value to the agent at each level.

BELIEF LOADING: The sensor input includes recognizers that update beliefs in current state, causal models, uncertainty, expectations with respect to estimates, or even changes of context (emergency overrides).

UNCERTAINTY MODELING: The value judgment function models the impact of uncertainty vs. the value of plans considered, refining the subplan requirements in the light of partial completions, monitoring execution, and preventing biases. Hypergame theory helps us to conduct this tradeoff (next page).

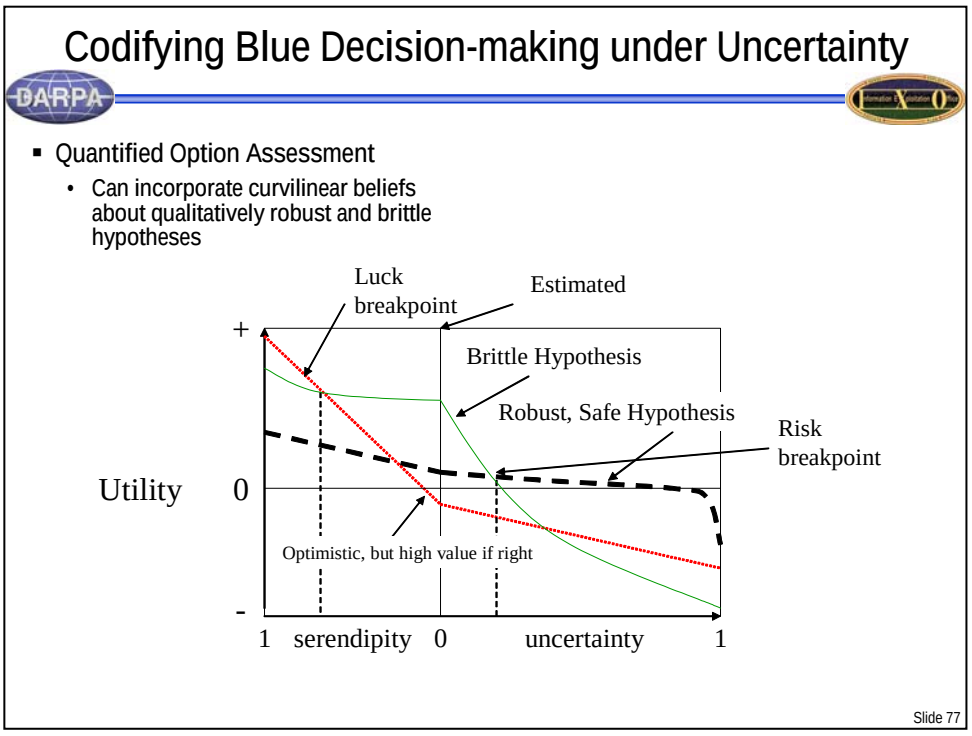
STRATEGY VALUES: The behavior generators in subordinate cobots are given strategy directed goals, not global goals to reduce the required search space for optimal plans and to achieve the benefits of specialization. Often the *means* remain opaque to the higher level agent that focuses on goals at a higher level of abstraction.



Consider the traditional approach to determining COA generation. In this simple hypothetical case, we presume that we have perfect information about the current situation (figure above, left). We evaluate four courses of action (COA 1…4) and excursions over those COA's by running simulations to determine the values of the effects of each. In this case, any uncertainty in the outcomes is considered to be attributable to uncertainty in the models included in the simulation.

Next, consider the more realistic case in which there exists significant uncertainty in the description of the situation itself. The figure above (right) illustrates this case by describing the current situation as a matrix of possible situation descriptions over a range of parameters that describe uncertainty (e.g., in terms of civil parameters described earlier in this document). The simulation now creates a multidimensional "landscape" of results, with each point on the effects surface being a single simulation outcome. The landscape now represents the uncertainty in effects attributable to uncertainty in both the current situation and the models.

This landscape of effects creates a more complex – yet more representative – description of our knowledge of the potential effects of our actions and requires a method to assess the options that evaluates a value function over the entire landscape of beliefs, values associated with the effects (consequences), and uncertainty.

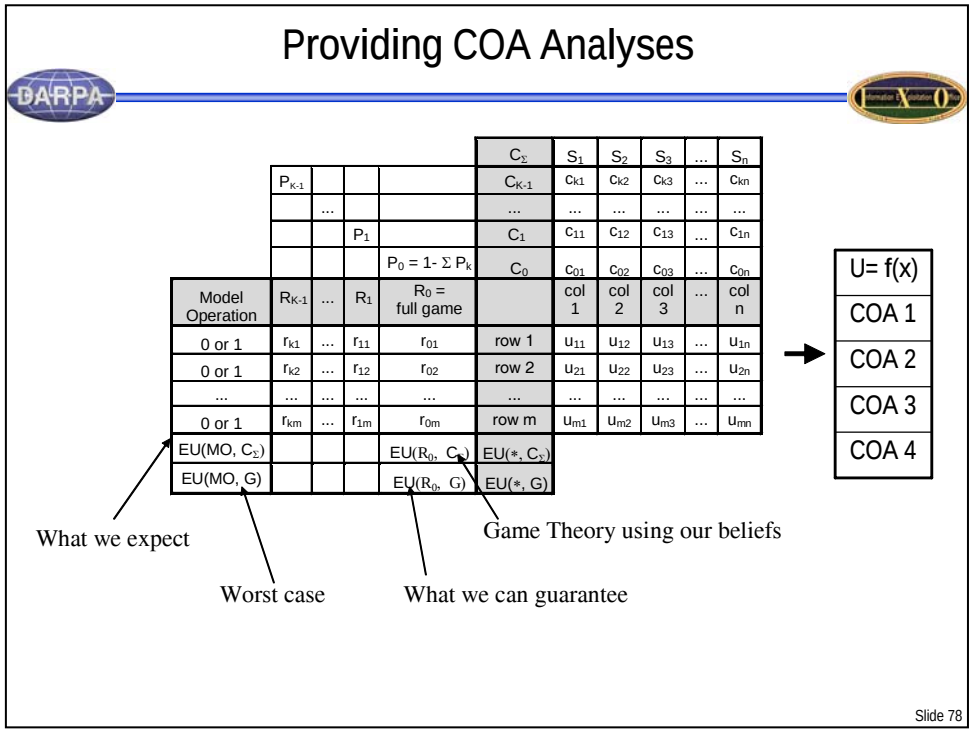


Hypergame theory and its recent extensions provide a promising foundation for reasoning about beliefs, value, and uncertainty. Quantified Option Assessment (QOA) is a hypergame theory-based process for evaluating the Utility of alternative decision strategies while considering the uncertainty in the current situation, as well as the uncertainty in the projected utility of alternative strategies (or hypotheses).

As illustrated above, the QOA process allows the analyst to consider an overall utility function (U) across alternative strategies, evaluating the effectiveness of any strategy over the *range of uncertainty* in the modeled estimate of the current situation. To the right of 0 are worse-than-estimated cases and to the left are better-than-estimated cases (serendipity).

QOA provides the analyst an overview of the entire spectrum of possible realities, rather than just the current point estimate of the situation. In this way it quantifies the Utility across all possible realities for a number of strategies. The "flatter" the curve of a strategy, the "safer" the plan.

A current version of QOA is implemented in Java 1.4, built for DARPA/ATO's *Dynamic Coalitions* program.



The hypergame normal form matrix (above) relates the following variables:

- Summary Estimates (upper right corner) are alternative estimates of the current situation in C_0-C_{k-1} competing estimates about the future (columns) and S_n final m probability vector of belief about the current situation.

- Utility submatrix of the matrix (lower right hand corner) contains U_{mn} are the Utility values of the m friendly course of action (rows) and the n possible situations (columns) .

- Beliefs in Current Situation Diagonal (upper left) is a diagonal of probabilities of belief in the competing estimates C_0-C_{k-1}

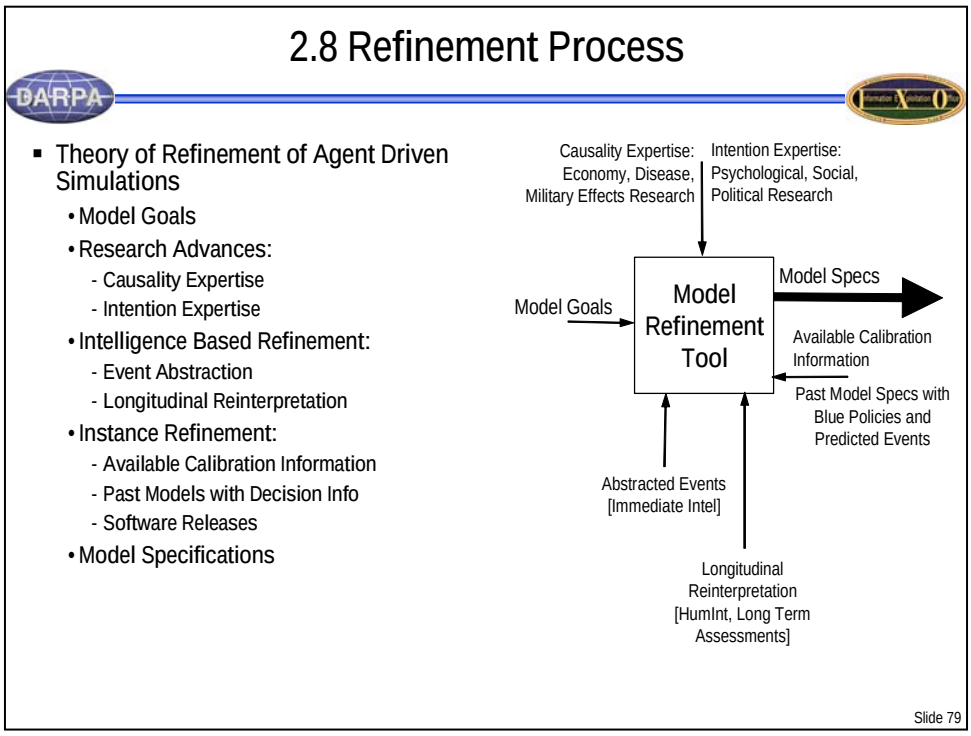
- Opponent strategies (lower Left submatrix) includes the mixes of opponent strategies R_{km}

Once the hypergame is described, the lower left two rows allow us to compute the expected utility, EU, for pairs of possible R_{km} opponent strategies and own strategies. The EU values of what is expected, the worst case, what can be guaranteed, are computed, in addition to the traditional, single-valued, game theoretic solution for the current estimate of the situation.

The normal form matrix allows computation of the Utility U = f(x) over alternative courses of action, COA $_1$, COA $_2$ ... COA $_n$.

2.8. Refinement Process

The refinement process is required to update the EBO models as time progresses for two reasons: 1) to correct model errors and inaccuracies due to missing variables, and 2) to adapt models to changing behaviors of adapting model subjects.



A theory of refinement of agent driven simulations requires a means to observe real-world responses of modeled subjects to stimuli and means to compare that response to current model behaviors. Based on this comparison, agent parameters and modeled goals may be refined to adapt to the target population. A model refinement tool (above) requires the following inputs:

- Model Goals – the estimated goals of the population (ideological, economic, physical, etc.)
- Agent Behavior – the causal (e.g. economic, health, physical, environmental) and intentional (psychological, social, political) factors that describe the aggregate behavior of the population
- Two sources of intelligence based refinement data must be considered:
  - Event Abstraction – the observed responses to point events
  - Longitudinal Reinterpretation – the inferred long-term trends in attitudes, perceptions and goals based on longer-term assessments
- Instance Refinement – Individual instances can be refined using available calibration information, and past models with decision information (this is described on the next page).

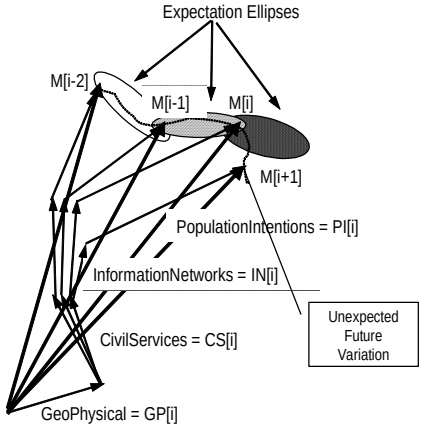
The output of the tool is an agent model specification update to refine the agent models.

Instance Refinement

- Available Calibration Information
  - Software Releases
- Prior Model Information
  - Past Model Specification
  - With Past Blue Policy
  - Predicted Events
  - Actual Operations Info, if available

M[i] = GP[i] U CS[i] U IN[i] U PI[i]

$$\frac{\partial M}{\partial t} \approx \frac{\partial}{\partial t}\begin{bmatrix} GP_1 & \dots & GP_k \\ CS_1 & \dots & CS_l \\ IN_1 & \dots & IN_m \\ PI_1 & \dots & PI_n \end{bmatrix}$$



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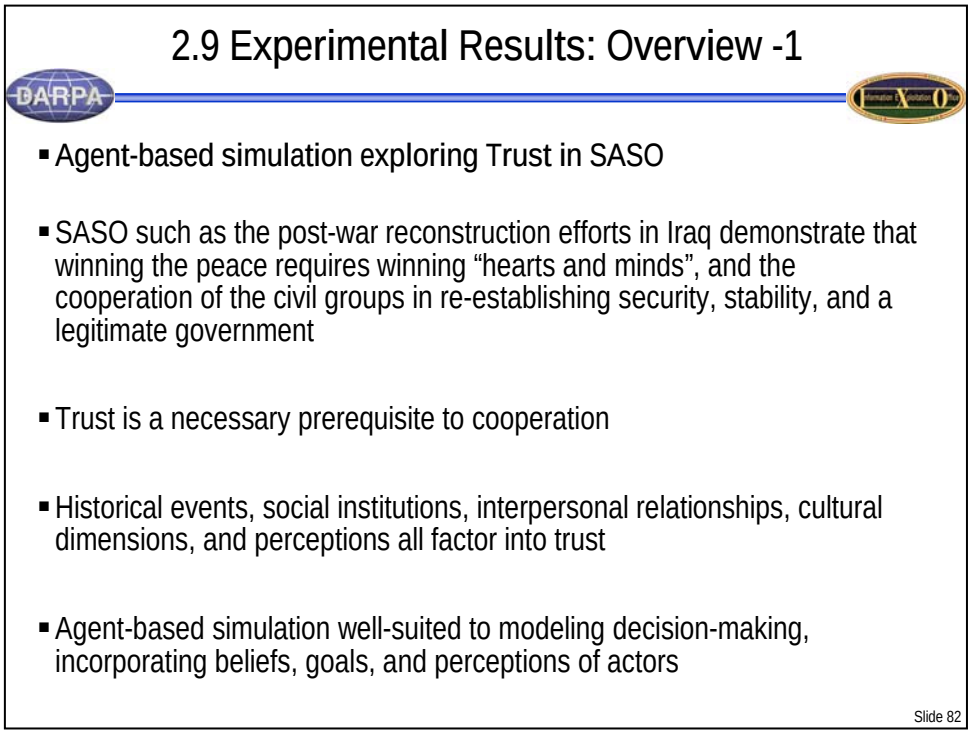
A single instance refinement is illustrated above, where a single (simulation behavior) instance is represented by the i^{th} vector outcome, M_i, made up of the linear sum of geophysical GP_i , Civil Service CS_i , Information Network NI_i, and Population Intentions PI_i, vectors. The time sequences of expectation ellipses in Mi illustrate the expected variation in each prediction (anticipation) of behavior.

The models are based on pre-conflict information, which are used to abstract events and translate them in to actions/results, requiring interpretation and annotation of data.

Multiple versions of the agent based model may be maintained (e.g. responsiveness is strongly aggressive, mildly aggressive, aggressive, or neutral) and their predictions compared to current observed behaviors to detect changes in behaviors (based on changing beliefs, perceptions, goals) and to adjust the selected model for EBO predictions.

2.9. Experimental Results

A prototype agent-based simulation was conducted to evaluate one aspect the challenge of simulating foreign civil population behavior. This section describes the experimental approach and results of a simulation of trust of a subject population, represented by a single SOAR agent to illustrate the potential of such technologies.



Among other things, combat and SASO operations include an important effort to win civil population hearts and minds: that is, it is a matter of winning trust. In order to win the hearts and minds of the population such that the US can accomplish its mission, the US must first establish an environment of trust and cooperation among the relevant parties. Without some level of trust from the population to the coalition forces, in terms of maintaining security, establishing a legitimate government, etc., the coalition faces an even longer road to nation building in Iraq.

We describe here a basic agent-based simulation test bed for exploring the role of trust in SASO, and describe some experiments designed to identify important characteristics regarding trust in that environment. We adopt an agent-based approach due to its suitability for representing different decision-makers in a space, including beliefs, goals, and perceptions of actors and events. Additionally, the interactions of goal-directed agents in the simulation capture the non-linear aspects of reality by modeling local phenomena to achieve global patterns.

Experimental Results: Overview -2

- Two components in agent-based simulation testbed:
  - Multi-agent interaction model
    - "Resources" is the basic currency; can be donated or (attempted) to be taken
    - Simple combat model for attackers/defenders; collateral damage
    - Communication about own or other resources, and about attack/donation events
    - Agent policies determine actions (e.g., "Attack when force ratio is greater than 3:1")
    - Agents can only attack when they know other agent's resource level > 0
  - Trust model
    - Trust is a combination of *specific trust* based on interactions with a specific agent and *generic trust* based on presumptions about different agent categories
    - Four major characteristics of specific and generic trust:
      - Competence (C): agent's ability to meet goal Benevolence (B): agent acts in interest of trustor
      - Integrity (I): agent's tendency to fulfill promises Predictability (P) : agent acts in consistent manner
    - Trust is weighted sum of characteristics; weights reflect importance of particular characteristic

$$\text{Overall Trust} = \text{Specific} + \text{Generic} = \frac{(w_c C_s + w_b B_s + w_i I_s + w_p P_s + w_{gc} C_g + w_{gb} B_g + w_{gi} I_g + w_{gp} P_g)}{(w_c + w_b + w_i + w_{p+} w_{gc} + w_{gb} + w_{gi} + w_{gp})}$$

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The agent-based simulation is made up of two components: an agent-based interaction model enabling cooperation and conflict, and a trust model augmenting the interaction model. The interaction model consists of a set of agents, each with a certain amount of resources that can be used to attack or donate to other agents. Donations are a straightforward transfer of resources. Attacks are put through a simple combat model that computes losses for both sides based on force ratios. Additionally, collateral damage can be computed for bystanders. Agents can also communicate with other agents regard events that have happened (attacks or donations) and the resources of themselves or others they know about. There are basic simulation rules, such as an agent can only attack when the defender has more than zero resources allocated.

For trust, we present a partial implementation of the Huff and Kelly model [26] as an additional component to the agent interaction model. This model distinguishes between specific trust (toward a specific agent) and general trust (toward a category of agents). Each of these types of trust is composed of four basic characteristics, as defined by McKnight and Chervany [27]: benevolence, integrity, competence, and predictability. Benevolence is the tendency for the trustee to act in the best interests of the trustor. Integrity is the tendency for the trustee to fulfill its promises. Competence is the ability of the trustee to meet its goals. Predictability is the tendency for the trustee to act in a consistent manner. From this, we define trust as a weighted average linear combination of these

[26] Huff, L. and Kelley, L. (1999) "Trust Formation in Collectivist and Individualist Societies", In Proceedings of 8th Cross-Cultural Consumer and Business Studies Conference. December 12-15, 1999. Cancun, MX.

[27] McKnight, X., and Chervany, X. (2001) "Trust and Distrust Definitions: One Bite at a Time." In *Trust in Cyber-societies.* Springer-Verlag: Berlin.

characteristics for both specific and generic trust. Weights are provided for each characteristic to denote the importance of that characteristic to the trustor. Agents follow basic policies for deciding when to attack, donate, or communicate with others.

Experimental Results: Setup

- **Experiment:** Simple 3-agent Model

Agent	Policies
Population	▪Announce Red attacks (includes resource info) ▪Tell Blue about Red resources if Trust > cooperation threshold
Red	Attack Population or Blue whenever possible
Blue	Attack Red when force ratio > 3:1

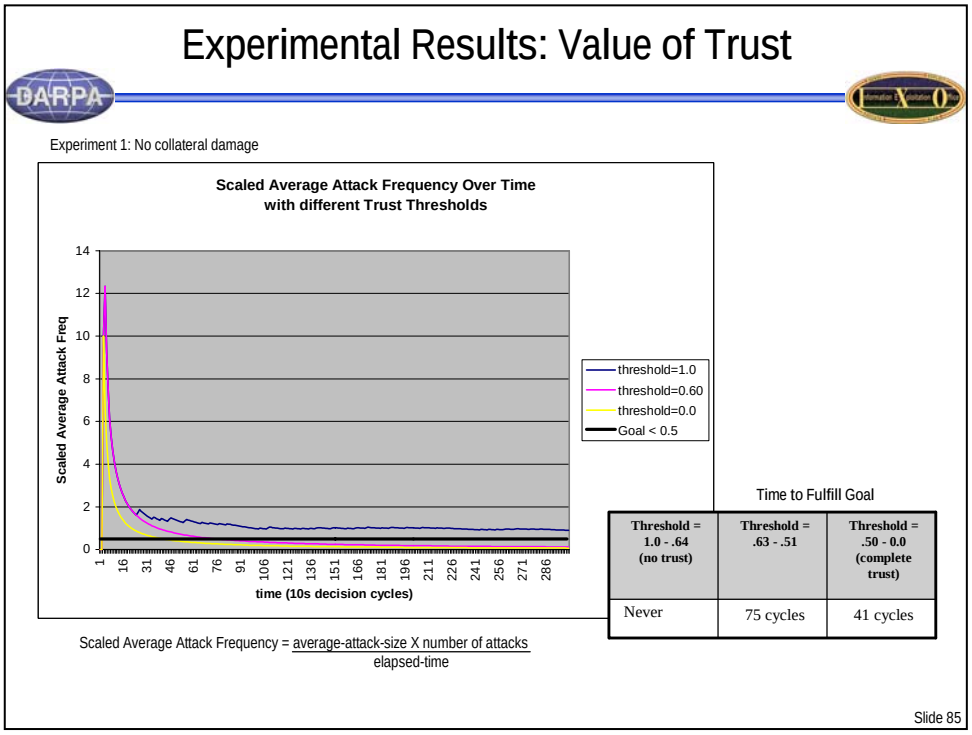
- **Assumptions:** Population always knows about Red's resources; selectively chooses to tell Blue
  Ignore generic trust in this experiment
- **Population's Goal:** Reduce frequency and scale of Population's losses to < 0.5 per cycle
- **Question:** What is the effect of Population's trust for Blue on the time to accomplish goal?
- **Method:** Run system using a range of Cooperation Thresholds (complete trust (0.0) to no trust (1.0), 0.05 interval) over 300 cycles, see how long before goal is met

Slide 84

The first scenario we explored was a three-agent situation in which a Population is being attacked by the government forces (Red), and Blue forces are in place to protect the Population. This sort of scenario was played out in recent conflicts such as Operation Allied Force (Kosovo). In this scenario, we assign a single goal to the Population: reduce the frequency and scale of its losses to 0.5 resources per time unit. As a baseline, Population always tells about Red's resources when Population is attacked, but that information may not be accurate (Red may not attack with all its available forces) and may not be timely (Blue may only be able to act some time after the attack occurred, which means the information is out of date). Also, Red always tells Population about its resource levels.

Trust is manifested in the Population's willingness to cooperate with Blue by telling Blue about Red's resources when they are known. We use a Cooperation Threshold to determine at what level (trust > threshold) the Population will start telling Blue about Red's resources. The question, then, is what effect does trust have on the time it takes for the goal to be accomplished?

The method here is to run multiple simulations, incrementally varying the Cooperation Threshold, to see how long goal achievement takes under varying thresholds. We run the gamut from complete trust (threshold = 0.0) where Population always tells Blue, to zero trust (threshold = 1.0) where Population never tells Blue, with increments of 0.05.



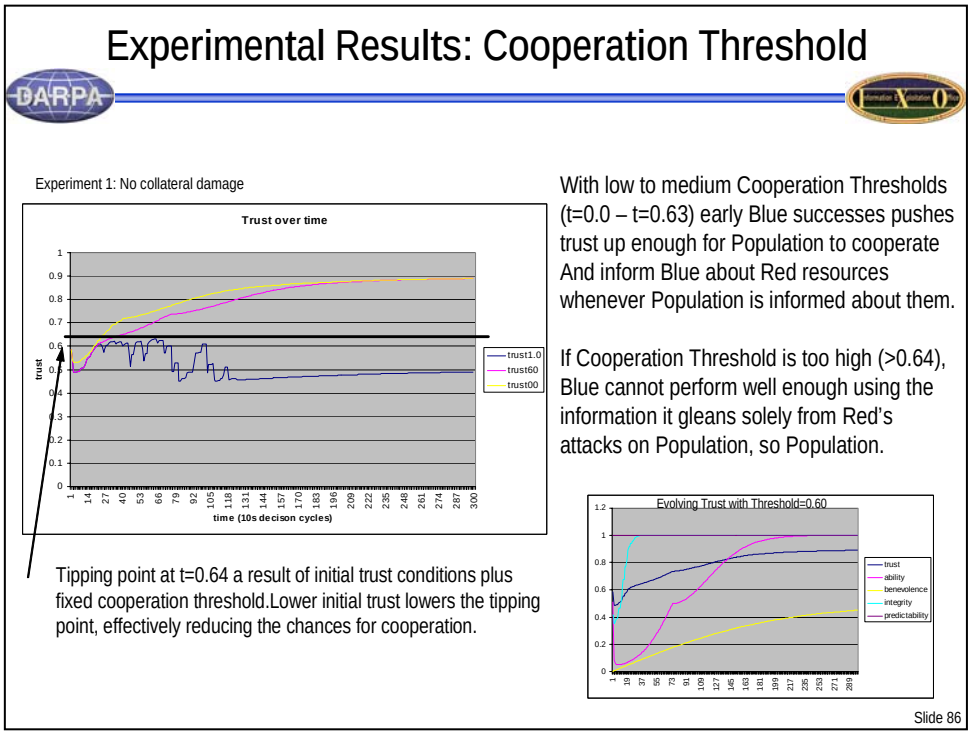
The goal is defined in terms of Scaled Average Attack Frequency. Scaled Average Attack Frequency is a measure of the average number of resources used to attack the Population (average-attack-size) times the number of attacks, divided by the total elapsed time. Here, the goal was to keep this value below 0.5.
The results for the simple three-agent scenario are presented above. The initial spike is simply an artifact of the running average used to compute the scaled average attack frequency. At 0 time units, the average is 0; at the first attack, the average spikes, then slowly comes down. Partly in the name of clarity, we present only three runs through this space, with thresholds at 0.0 (complete trust), 0.6, and 1.0 (no trust).

The base results here reflect what is somewhat intuitive: the more Population trusts Blue, the quicker the goal is achieved. At threshold=1.0, the goal is not achieved within the given run. At threshold=0.6, the goal is achieved within 75 time units. At threshold 0.0, the goal is accomplished within 41 time units.

The three runs we show in the above graph was not arbitrary. In fact, the three bins are pretty strong attractors: after around 200 cycles, these are the only three averages that exist, within a standard deviation of 0.0. With Cooperation Thresholds above 0.64, the goal is not accomplished in the 300 time units run (though might after much longer). With the Cooperation Threshold between 0.63 and 0.51, goal achievement takes 73 time units. With a low threshold between 0.0 and 0.50, goal achievement takes only 41 time units.

The model exhibits quite a bit of sensitivity to initial conditions such as force ratio between Blue and Red, and initial trust values (generic trust). For example, if generic trust is reduced, the overall trust results are discounted by the same amount, and the goal takes longer to achieve, proportional to the discounted

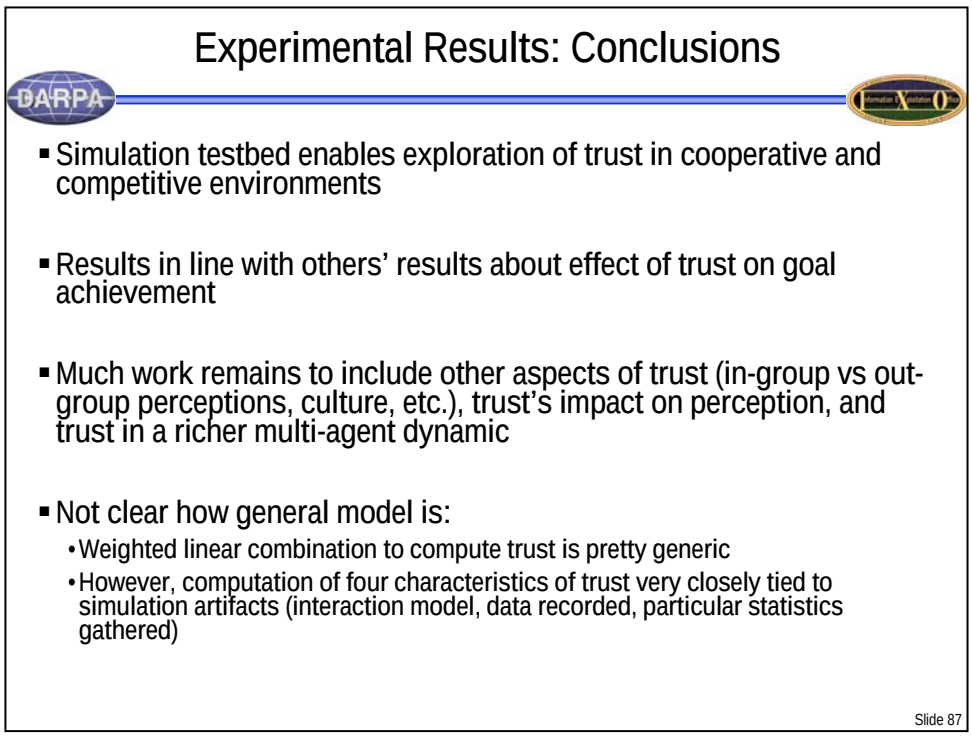
amount. So, in fact, this translates to the quicker Population consistently trusts Blue, the quicker the goal is achieved.



The above graph shows the evolution of trust over the duration of the experiments, for the three previously mentioned thresholds (t=1.0; t=0.6, and t=0.0). The inset shows the evolution of the components of trust for the t=0.60 case. Here, predictability is held constant. Benevolence is computed based on the frequency of attacks on the Population (Blue does not attack Population). So, in this scenario, Integrity and Ability play the largest role. Integrity is the measure of the trustee's tendency to fulfill its promises. In this model, Blue has an implicit promise to protect the Population. Also, trust is improved when the trustee shows an ability to achieve the goal – in the graph, we see a visible bump appear at around time=75, corresponding to when the goal threshold was crossed for this case.

The oscillation that is visible in the t=1.0 case is a reflection of the inability for Blue to gain a foothold enough on Red to reduce the Scaled Average Attack Frequency. When the information coming to Blue is based solely on Red's attacks on Population, which (as previously noted) are infrequent, and may be inaccurate and out of date, Blue cannot compensate enough to meet the goal.

A tipping point at t=0.64 is clearly visible, where trust above that point converges above the Cooperation Threshold, and trust below converges below. The tipping point is a confluence of a few factors. As mentioned previously, because the initial conditions result in trust near 0.5, and using the fixed Cooperation Threshold, very quickly we see these three trust trajectories arise, corresponding to the three intervals [t=1.0-0.64, t=0.63 – 0.51, and t=0.50-0.0], where the latter two intervals result in eventual goal achievement, and the high interval does not.



The model presented here gives a view of trust in multi-agent interactions. Clearly, more work needs to be done for the model to exhibit the richness we see every day in the news reports about the progress being made in Iraq. However, while the model is still quite underdeveloped, the results shown here are in line with other research done on trust (see, for example, Prietula [28]). Additionally, the model developed has potential for exploring many other elements of trust including cultural factors as shown in Huff and Kelly and others. The adoption of this model as the basis for Trust computation allows a broad exploration of the effects of trust, and the factors that influence trust itself.

What is not clear at this point is how general the model is. The basic model that trust is composed of specific and generic trust, and even the linear combination of factors, is certainly quite generic. However, the individual characteristics of trust are each computed in terms of very specific simulation artifacts. For example, we use statistics such as time since last attack, scale of attack, and goal achievement to compute benevolence, integrity and competence. It's perhaps reasonable that these same statistics might be drawn from a richer simulation. However, it may be that there are other statistics available in that richness that could be used in these computations.

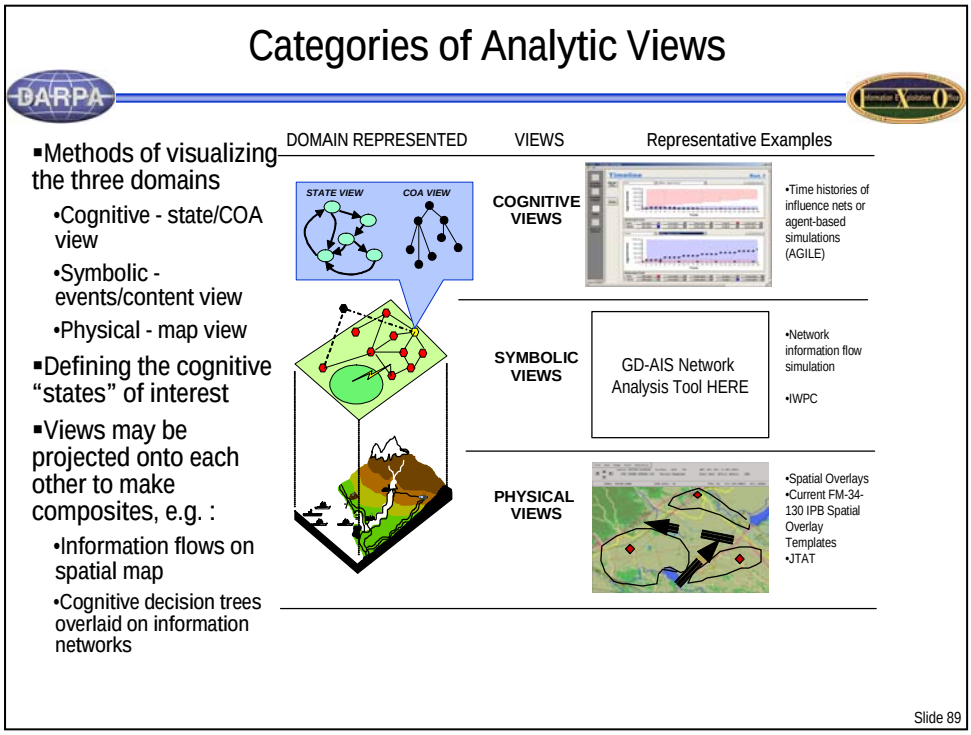
Regardless of these drawbacks or simplifications in the current model, the research that went into its development, and even some of the results, indicate

[28] Prietula, M. (2001) "Advice, Trust, and Gossip Among Artificial Agents." In Lomi, A, and Larson, E. (eds) *Dynamics of Organizations: Computational Modeling and Organizational Theories.* Cambridge, MA: MIT Press.

that trust relationships must be represented in a simulation that means to take into account civil intelligence.

2.10. Visualization, Reporting, Dissemination

While there exists significant capability to visualize scientific data and military geospatial intelligence, Urban Sunrise must develop new methods to represent non-traditional information on symbolic and cognitive "targets" and their non-material effects.

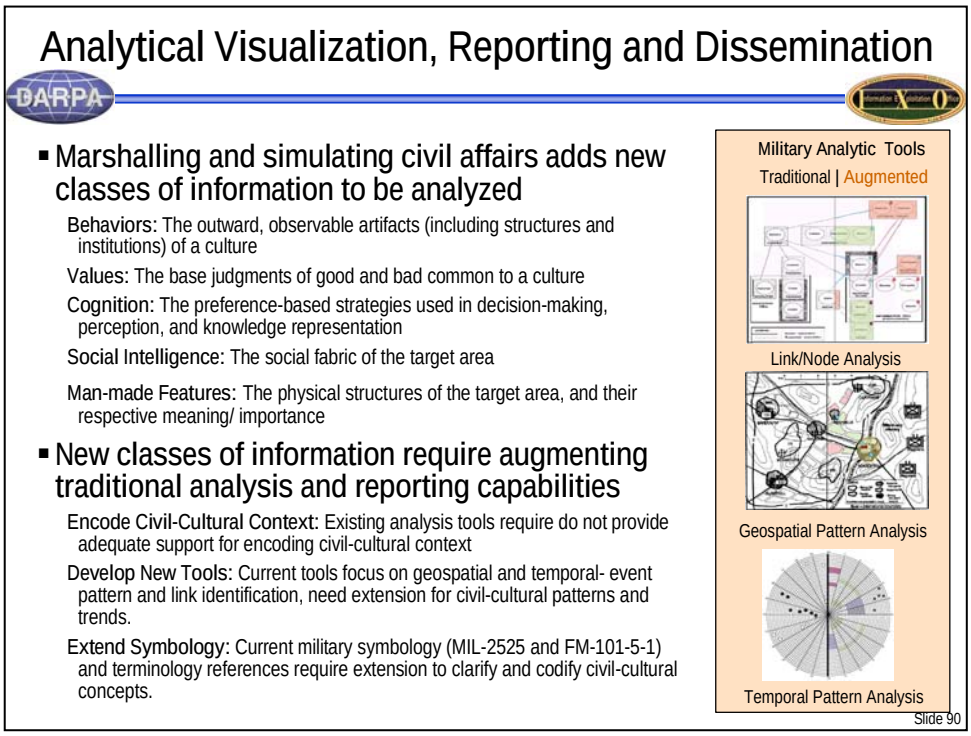


The Urban Sunrise knowledgebase and EBO simulations must provide visualizations of abstractions in the symbolic and cognitive domains for both analysis and operations planning. The visualizations must show high dimensionality civil information, for example:

- Civil "health metrics" that describe the physical and mental states of various population groups within an urban area.
- Civil population perceptions, beliefs, behaviors
- Complex Human Behavior : States, Modes, Shifts

The visualizations must present, in a compact and efficient manner, this information for civil intelligence analysts and planners, as well as for reporting, dissemination to non-technical users.

The chart above illustrates the three domains of information that must b represented, and the need to be able to correlate, or overlay, these domains to allow users to understand the effects of operations in all three views of reality. The Urban Sunrise program must develop product formats for Civil Information (e.g. Population Analysis Templates), tailored products, and composite overlays to represent his information.

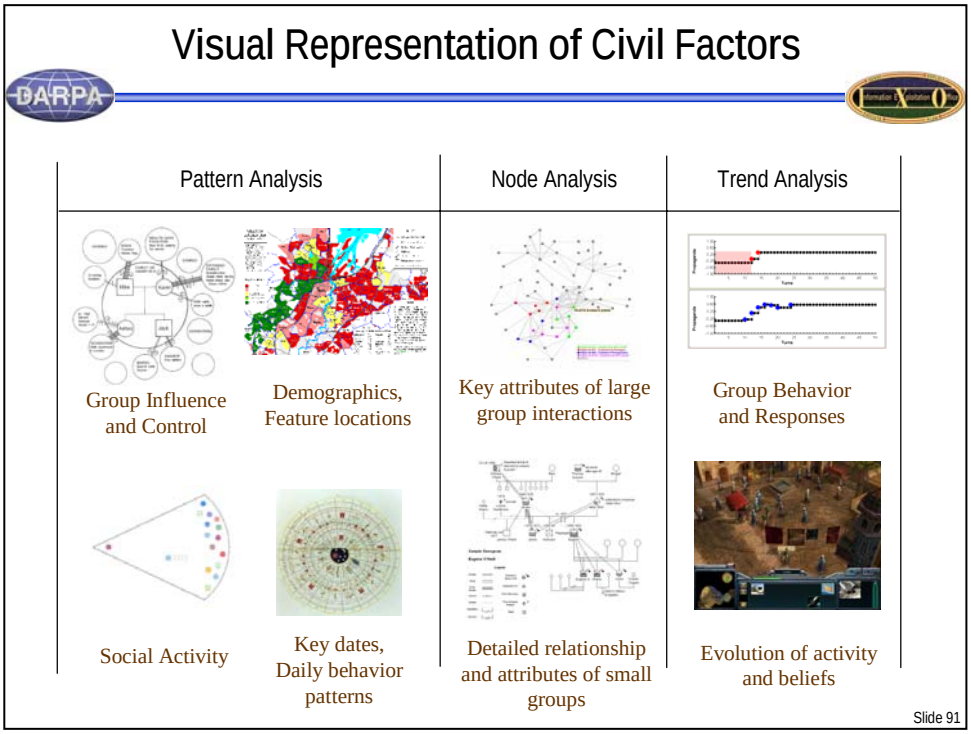


As described earlier, civil-cultural affairs add new classes of information to the analysis process. This information includes group and individual behaviors, values, cognitive characteristics and processes, as well as the social fabric and cultural features of the area. These classes of information traditionally have not been included in the military analysis process, though their inclusion is critical to successful urban and stability operations.

With the inclusion of new classes of information of any type, it is important to evaluate current analysis processes, tools and products to ensure that they incorporate and leverage the new information effectively. In the case of cultural-civil information, three tasks need to be undertaken as part this evaluation; developing mechanisms to encode civil-cultural context in existing analysis tools, developing new tools focused on exploiting the unique characteristics of the new information, and developing new terminology and symbology that captures critical features of the new information.

Traditional military analysis tools focus on link/node analysis and pattern analysis, usually focused on either geospatial or temporal patterns. These tools tend typically encode only a limited number of data types into them. This sparseness means that there is an opportunity to augment them with overlays that show additional information dimensions. For example, a link analysis of a terrorist cell can list not only the members of the cell and the cell's external contacts, but augment that information with cultural-civil background on each member, if known. This information could help anticipate group loyalties and schisms as well as point to opportunities for external manipulation and disruption. Temporal pattern analysis can be greatly augmented by annotating dates and times with

the holidays and daily life activity patterns of a region, for example market days, prayer times, and days of public celebration.



Various communities outside of the military have developed visual displays/representations that can be leveraged to construct new tools for military use or to inform how cultural-civil information can be encoded into existing displays. These communities have little in common other than sharing a range of cultural-civil issues. These communities include various scientific disciplines including anthropology, sociology, psychology and computer and information science, medical and social service practitioners, marketers and design ethnographers, a range of artists including painters, dramatists, cinematographers and software game designers.

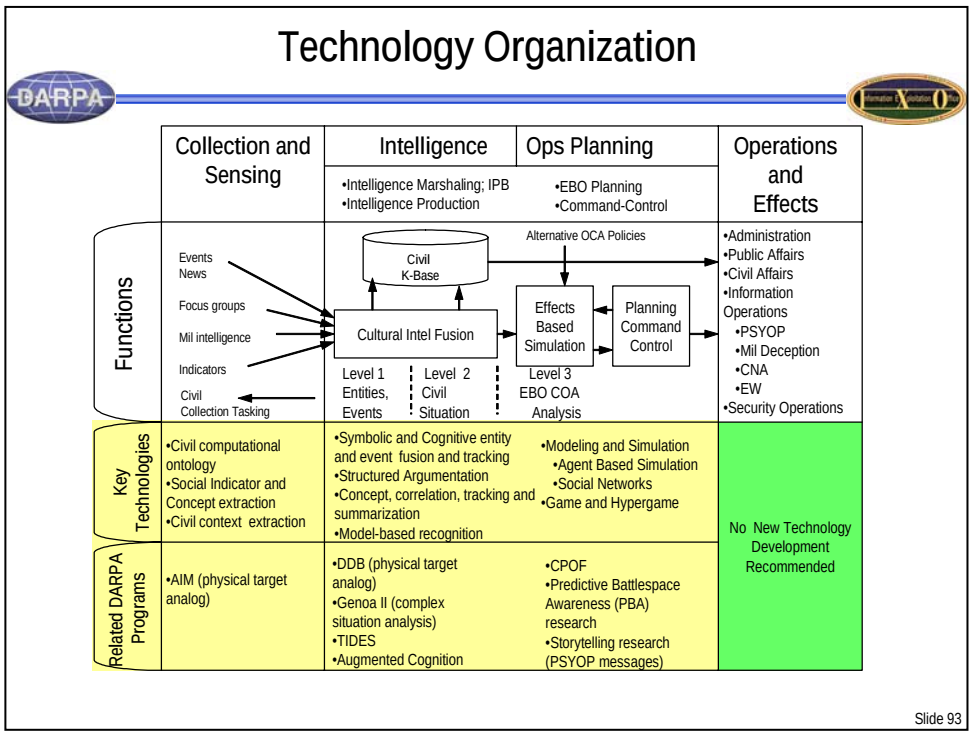
The images above show a sampling of representations. The slide focuses on graphic displays because the existence and range of available graphic forms is surprising, though it should be understood that an equivalent range of textual representations exist that should also be considered. Textual representations include simple list and matrix forms, as well as more specialized shooting or drama scripts, news paper formats, lexiconic and encyclopedic forms, and a range of structure text reporting formats, including a range of military forms.

What the forms above generally have in common is that they place civil-cultural features as the primary artifacts of analysis. This allows them to clarify difficult concepts like group influences (Ecogram, top left) and temporal patterns (Mexican calendar, bottom second from left), concepts that are often obscured other representation techniques.

It is not necessary that military systems designers directly incorporate any of the displays shown here, with careful analysis of these forms the techniques that underlie them can be extracted and applied in the military context.

3. TECHNOLOGIES

The organization of key technologies required to provide the urban Sunrise capability, summarized below, span the traditional DARPA IXO areas of technology development from collection and fusion through operations analysis and planning- typically in command and control programs.



The three primary areas of technology development include:

Civil Intelligence Collection and Sensing – A civil computational ontology must be developed to represent civil intelligence, as well as means to extract social indicator and civil intelligence concept from source data and new technical sensing methods to directly observe and extract civil intelligence. These developments are similar to DARPA special sensor developments and the AIM program for collection management (a physical target analog).

Civil Intelligence Data Fusion - Symbolic and Cognitive entity and event fusion and tracking technology must be developed, including technologies to perform structured argumentation, concept, correlation, tracking and summarization, and model-based recognition of civil activities. The work on related DARPA programs is highly relevant: DDB (physical target analog), Genoa II (complex situation analysis), TIDES, and Augmented Cognition.

EBO Operations Planning – Effects based Human Behavior Modeling and Simulation will require the development of social network modeling and Agent Based Simulation technologies. Relevant DARPA programs include CPOF, Predictive Battlespace Awareness (PBA) research, and storytelling research (PSYOP messages).

A technology assessment of challenges and related DARPA technology activities in each of these three areas is provided in the following table to illustrate the relationship of Urban Sunrise technologies to similar technologies being developed to apply to traditional (physical) military target sets.

Technology Assessment Matrix

Area	Technical Challenges	Technologies and Related DARPA programs
Cultural Collection	Accurate collection extraction, and representation of civil data from existing and new technical sources;	• Civil computational ontology (DAML, RKF) • Civil automatic indicator recognition (Civil-ATR) • Social Indicator and Concept extraction from unstructured sources • Civil context extraction
Civil data marshaling, fusion and analysis	Automated and semi-automated civil intelligence knowledgebase creation; creation of civil data inputs for EBO models	• Symbolic and Cognitive entity and event fusion and tracking • Structured Argumentation • Concept, correlation, tracking and summarization • Model-based recognition

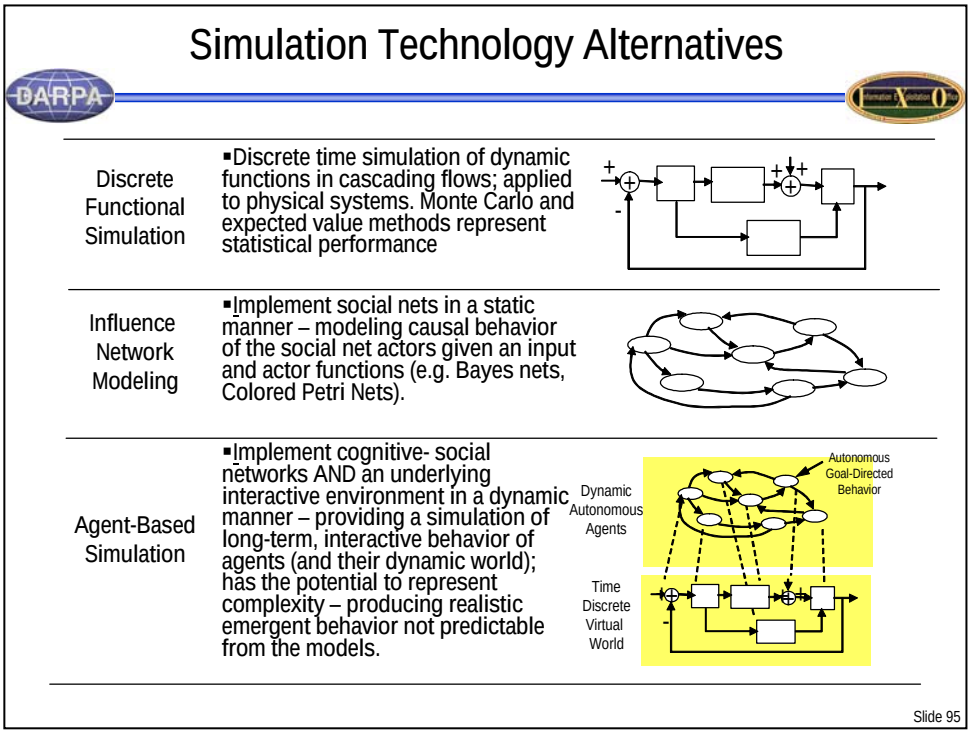
EBO modeling and simulation	Simulation of non-military operations, civil populations, and effects.
	Analysis of effects in complex and highly uncertain simulations
		• Human behavior Representation
		• Modeling and Simulation
		  • Agent Based Simulation
		  • Social Network Amalysis
		• Game and Hypergame
		• Complexity of Effects-space analysis (Genoa II)

The chart on the next page compares the three alternative simulation technologies that can be applied to the central Urban Sunrise challenge of dynamically representing the overall civil system.

Discrete time simulations, most often applied to physical systems, represent dynamic functions in cascading flows; providing accurate linear approximations to physical behaviors where components are represented by closed form (stochastic) equations. Monte Carlo and expected value methods represent the statistical performance of real systems. These models are appropriate for the systems of the physical and symbolic (information) domains of the Urban Sunrise simulations.

Human behavior simulations (the cognitive domain of the Urban Sunrise simulation) can be implemented in static social networks, or in dynamic agent based simulation.

> Social Influence Networks - Implement social relationships in a relatively static manner, modeling causal behavior of the social net actors given an input and actor functions (e.g. Bayes nets, Colored Petri Nets).
>
> Agent-based Simulations -Implement the cognitive- social networks AND an underlying interactive environment in a dynamic manner, providing a simulation of long-term, interactive behavior of agents (and their dynamic world); has the potential to represent complexity – producing realistic emergent behavior not predictable from the models.



A number of related approaches are applied to independently modeling the three domains of reality described in this proposal. In this section we compare the proposed approach with alternative approaches that have been proposed or developed within the research community. To compare related research that may support urban operations analysis and operations planning, we distinguish the fundamental difference between the proposed approach and the majority of current work. The table below illustrates the two fundamental implementation dimensions that define the modeling and simulation approach that may be chosen:

Alternative Solution Approaches

Model Implementation **Model Structure**	**Analytic Linear Simulation**	**Synthetic Complex Adaptive System Simulation**
Ontologically -Based 3 Domain	• Linear dynamic knowledge sources in computational ontologies	• Agent-based Simulation **URBAN SUNRISE**
Functionally -Based Multi-domain	• Monte-Carlo Simulation – coupled differential equations • Bayesian causal networks	• Agent-based Simulation • Influence Net Dynamic Systems Analysis

Model Structure – The approach to relating the model to reality may be ontological, or functionally-based. An ontologically–based 3 Domain structure formally organizes all functions and interactions around the 3 fundamental semiotic[29] domains of reality: cognitive, symbolic and physical realities. Functionally–based multi-domain simulations apply informal or *ad hoc* approaches to define models based on important functions and influences, but not related to higher order ontology. The URBAN SUNRISE approach follows the formal semiotic ontology that maps and models all relevant functions to each of the three realities. Traditional, functionally based approaches define and interconnect models on a more *ad hoc* basis, selecting functions on the basis of problem importance.

Model Implementation – A number of methods may be chosen to implement the descriptive models of reality, and to simulate the dynamic interactions of players. The fundamental design option, however is to choose traditional linear (deterministic or non-deterministic) approaches (e.g. Monte Carlo simulations, or Bayesian causal network models), or simulations that are designed to represent high-levels of interaction and feedback to produce complex behavior. Numerous current leadership and command and control modeling efforts have applied Bayesian, Petri or deterministic influence networks to represent the social networks of people and their interactions with command and control or weapon systems.[30] The URBAN SUNRISE approach uses an agent-based simulation to represent the many levels of interaction between human decision-makers and separate dynamic models of information flows and physical activities within the urban space. The agent based simulation provides agent-actor autonomy to produce a large envelope of possible behaviors.

The URBAN SUNRISE approach can be compared to other agent-based human dynamics research simulation approaches to illustrate the two characteristics that distinguish the tool relative to other simulations:

World Model Complication – is not as detailed as CIA/SAG linear economic models, for example, but is has much greater detail than the very basic "worlds" that are used in fundamental agent-based research models.

Agent-Actor Complication – The simulation employs sophisticated Soar ("cognitive") agents that emulate human reasoning and goal-directed decision-making processes. These agents are therefore much more complex than the agents employed in other research simulations that seek to study high-level patterns of emergence form large numbers of low-level agents (e.g. Santa Fe Research Institute ECHO, SWARM, ONR Isaac/EinStein, Machiavelli, others).

Urban Sunrise researchers must monitor related academic and military research in this area (Table) to measure progress in the field, and learn from the results of similar research. The table summarizes the related research, source or performer, and a brief description of relevance to Urban Sunrise.

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[29] Semiotics is defined as the science of signs and/or sign systems; this approach is semiotic in that it recognizes that the symbolic or information layer mediates between the physical reality (mass and energy) and the mental reality of the mind (cognition and emotion).

[30] Robert S. Renfro, II, "Modeling and Analysis of Social Networks", Dept. of the Air Force, Air University, 13 December 2001.

Representative Related Research

Research	Source	Description and Relevance to Urban Sunrise
Project Scenario – AGILE Advanced Global Leadership Experiment	Intelligence Community ITIC	Large-scale two-nation integrated analytic tool of competitive foreign leadership; agent-based simulation includes a virtual world model of the symbolic and physical attributes of a nation-state.
Human Behavioral Dynamics Modeling	ARDA - DIA	Six academic studies of human dynamics models, including agent-based simulations of small group decision-making dynamics to represent military leadership group behavior
Social Network Modeling	Intelligence Community, JWAC, SAIC, others	SIAM influence net models used to model leadership decision-making, command and control and limited physical forces.
Academic Social Behavior Studies	Brookings, Santa Fe Inst, U. Penn. ONR, others.	Numerous academic research programs have studied social interaction dynamics (e.g. Brookings –Epstein, U. Penn –Lustick)
Joint Simulation System (JSIMS)	JSIMS Program Office	JSIMS has proposed an approach to "multi-domain" modeling that integrates social nets with many layers of actors.[31]
Information Operations Modeling and Simulation	NSA - Naval Postgraduate School	Application of SIAM Influence net modeling tool to evaluate military *Evident Surprise* scenarios and assess the use of M&D to plan information operations.
Wargaming Asymmetric Environment	DARPA IXO	DARPA modeling of asymmetric threats to predict potential behaviors based upon prior patterns. The problem requires abstraction and modeling of threat groups.
Human Performance Working Group	Defense Modeling and Sim Office DMSO	Reports results of research in modeling and simulation of human behavior, and verification and validation methods for human simulation
Counter-terrorism Simulation	Titan Corp.	Multi-domain model concept development based on 5 ad hoc domains (physical, political, legal, information, financial)
Analytic Decision Support	Navy N6, MOVES Institute	Analytical decision-support using synthesized adaptive agent-based and mathematical modeling.
Counterplanning Simulation of Information Warfare	Navy N6, MOVES[32] Institute	Information operations planning tool that considers networked decision making effects.

[31] Stone, George and Roger Smith, The Homeland Security Simulation (HLS-Sim), International Federation of Operations Research Societies Conference, July 2002.
[32] MOVES is the Modeling, Virtual Environments and Simulation Institute of the Naval Post Graduate School.

A recent analysis of Effects Based Operations (EBO) by the National Defense University concluded:

> The current suite of analytic tools employed by the Department of Defense cannot support the [EBO] approach to military operations. These tools were not designed to determine how the use of force affects adversary strategic will, to model adaptive behavior, to represent unintended consequences, or to evaluate alternative courses of action that include other instruments of national power beyond military force.[33]

The authors went on to identify eight specific "information sets" that must be modeled to support EBO; seven can be mapped directly in the URBAN SUNRISE 3 domain models proposed, and the eighth – *context* – encompasses the background to the other seven.

URBAN SUNRISE Addresses the Key EBO Information Sets

URBAN SUNRISE Domains	Effects Based Operations EBO Information Sets
Cognitive	• *Psychological* – Cognitive and emotive and other nonmaterial factors in human decision-making • *Sociopolitical* – social and political objectives and behaviors of agents, organizations and institutions. • *Organizational* - defines formalized relationships of hierarchies and networks created to achieve group objectives and carry out operations.
Symbolic	• *Infrastructure*, - combines technical and geographic information into a basic understanding of how objects and actors within the system relate to one another based on their technical capabilities. • *Dynamics* - the interrelations between physical systems and between physical systems and minds. .
Physical	• *Technical* – Physical characteristics of adversary military capability and resources • *Geographic* - relates objects, such as sensors, weapon systems, people, and other actors, to positions within physical space.

The recommended approach will provide a capability – tailored to the complex urban environment – that will pioneer the analytic technology to explicitly model civil intelligence targets, while enabling analysts and planners to explore the complexities of interactions between people, information, infrastructure and military forces.

[33] Saunders-Newton, Desmond and Aaron B. Frank "Effects-Based Operations: Building the Analytic Tools", *Defense Horizons*, Washington DC: National Defense University, October 2002, page 1.

4. MEASURING IMPACT

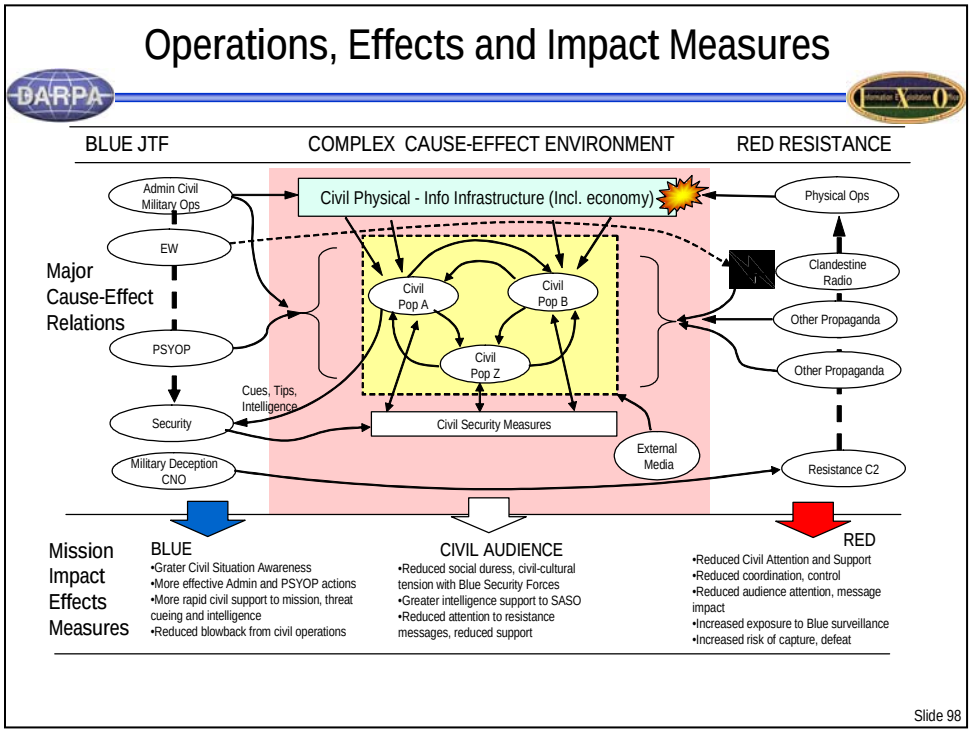
An essential element of the introduction of any transformational capability is the measurement of impacts of the capability on military outcomes. Because Urban Sunrise has both direct and indirect impacts on many factors involved combat through SASO operations, it is important to identify the linkages from improved intelligence, and operations predictions on mission accomplishment. In the recommended urban Sunrise program this may be performed in two ways.

First, the program must measure the *Impact* of the contribution of new Urban Sunrise capabilities at three levels of increasing abstraction:

- Civil Population Performance Measures (MOP's):
  - Increased Foreign Civil Intelligence in areas such as timeliness, accuracy, and depth of civil
  - Increased civil cooperation attributable to increased intelligence breadth, depth
- Operations Impact Effectiveness Measures (MOE's):
  - Civil Situation Awareness and the contribution of a commander's decision making and the degree of civil influence
  - Civil Situation Awareness and the contribution to Administrative, Information, and Military Op Effectiveness (outcome) Measures
- Military Mission Utility Measures include resulting Civil Stability in terms of metrics for security, civility, productivity, health, growth, and trust.

Second, the program must measure impact *relative to* three standards:

1. Current Practice – Capability must be compared to show the margin gains relative to unaided experienced judgment, and tacit knowledge of the urban environment
2. Alternative Military Missions – The capability must be evaluated for its contribution in pre-combat, combat, and Stability and Support Ops (SASO)
3. Alternative Operations – Finally, the capability contribution must be compared across Administrative, Information (IO), and Military security operations.



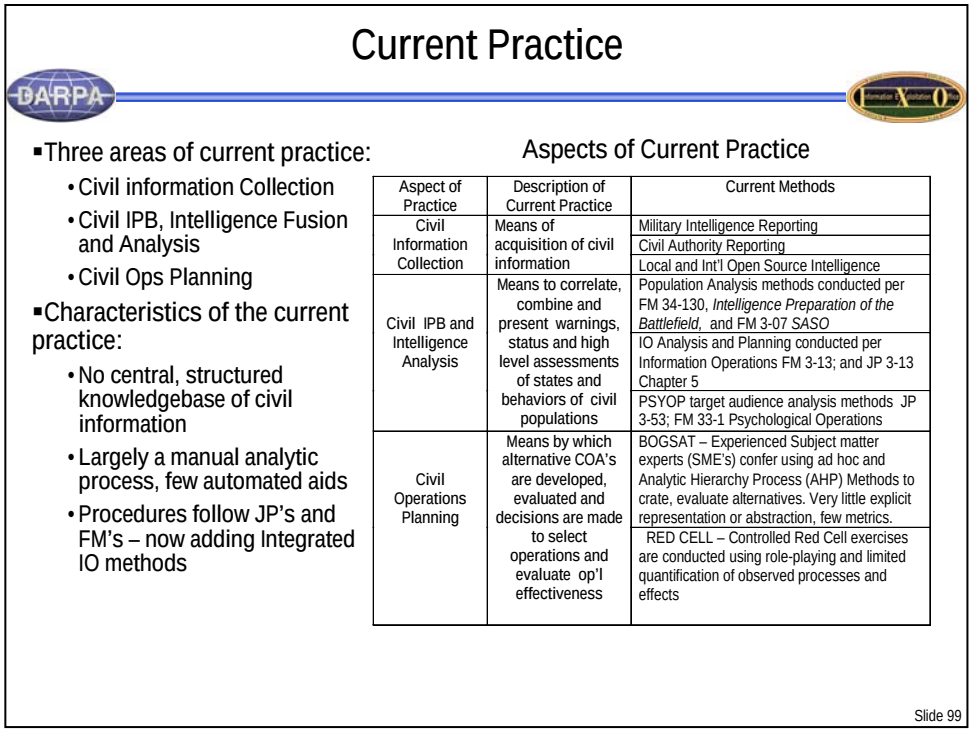
The influence diagram (above) illustrates the complex cause-effect relationship between Blue integrated operations and opposing Red (resistance, opposition, terrorist, and aggressor) operations on multiple, intertwined civil populations. The chart also lists the mission impact effects that must be measured.

The RAND Study "Street Smart: Intelligence Preparation of the Battlefield for Urban Operations" concluded that current practice could significantly benefit from Civil Intelligence capabilities that understand these complex interactions: [34]

- "A study of populations including demographic details, cultural norms, and perceptions should be incorporated in order to understand the indigenous culture. This is particularly true for the information operation component of any mission."

- "In addition to identifying "ground truth," IPB must address matters of perception. Each step of the IPB process should include questions about the public's assessment of ongoing events to ensure that friendly force activities are being interpreted as intended. …. Information operations can influence public opinion in a variety of ways. They are only effective, however, if a population's culture and perceptions are sufficiently understood."

[34] Street Smart: Intelligence Preparation of the Battlefield for Urban Operations, RAND MR1287, 2002



The current practices used in three areas are considered in the chart: Civil information Collection, Civil IPB, Intelligence Fusion and Analysis, Civil Ops Planning. The current practice is characterized by a lack of a central, structured knowledgebase of civil information, and remains largely a manual analytic process, with few automated aids. Analytic and ops planning procedures follow JP's and FM's. The Army is now adding Integrated IO methods (e.g. the Information Operations Planning Manual).

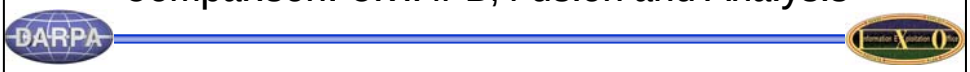
Current Urban IPB doctrine and practice includes the manual creation of civil overlays and templates, per: the following guidance

- FM 5-33, *Terrain Analysis*,
- FM 34-130, *Intelligence Preparation of the Battlefield,*
- MCWP 3-35.3, *Military Operations on Urbanized Terrain,*
- FM 90-10, FM 90-10-1
- Marine Corps *Urban Generic Information Requirements Handbook (GIRH)*

Current Urban Operations planning is conducted by collaborative discussions between experts ("BOGSAT's") where experienced subject matter experts (SME's) confer using ad hoc and Analytic Hierarchy Process (AHP) methods to create and evaluate alternatives. There is very little explicit representation or abstraction, and few metrics are used. Controlled Red Cell exercises are also (rarely) conducted using role-playing and limited quantification of observed processes and effects.

The new Urban Sunrise capabilities must be compared to these current practices to evaluate the contributions of a civil knowledgebase with full analytic capability (search-link-detection-discovery) and integrated effects tracking to provide predictive awareness of Civil EBO.

Comparison: Civil IPB, Fusion and Analysis



- Current Doctrine and Practice – manual creation of civil overlays and templates, per:
  - FM 5-33, *Terrain Analysis*,
  - FM 34-130, *Intelligence Preparation of the Battlefield,*
  - MCWP 3-35.3, *Military Operations on Urbanized Terrain,*
  - FM 90-10, FM 90-10-1
  - Marine Corps *Urban Generic Information Requirements Handbook (GIRH)*
- New Urban Sunrise Capabilities Compared:
  - Civil Knowledgebase analytic capability (search-link-detection-discovery) and effects tracking
  - Predictive awareness of Civil EBO

IPB Analysis Category	Analytic products
CURRENT static Population and Demographic Analysis	Population Status Spatial Overlay
	Congregation points Spatial Overlay
	Traffic Conditions, times, spatial overlay
	Likely Threat Locations
	Political Cultural event timelines
	Line of Confrontation matrix
	Organizational "Power" template
	SQABO(Status quo ante bellum) Animation
	Perception Assessment Matrix
	Relationship matrix
	Population OCOKA (Observation and fields of fire, concealment and cover, obstacles, key terrain, avenues of approach)
NEW Static	Civil data knowledge-base search and retrieval
	Civil data link and trend analysis
NEW Dynamic Tracking and Effects-Based Ops Projections	Population behavior dynamics tracking
	Population group interaction dynamics
	Civil stability metrics tracking
	Population group dynamics, response to ops
	Total Population response to operations

Slide 101

The chart above identifies many of the current manually produced analytic products defined in FM's 5-33, 34-130 and related documents, as well a several products that are recommended in the RAND Street Smart study.

While urban Sunrise will semi-automate the production of these current products, it will also produce a number of new products listed in the table:

- Civil Knowledgebase – One key product is the structured base of civil knowledge for search, retrieval and manual analysis.
- Civil linkage and trend analysis – The results of link analyses (e.g. relationships between groups, behaviors, and other urban factors) and trend analyses (e.g. temporal behavior of events, perceptions, activities, economic and social measures) are provided as products.
- Population group interaction behavior dynamics – The outputs of simulations provide products that enable decision makers to visualize and understand the complex interactions between major actors, and to understand complicated causal behaviors and emergent complex behaviors.
- Population group response to operations – The simulations provide products that represent the responses of individual population groups to alternative operations employed by coalition administration and forces.
- Total population response to operations – The simulations provide products that represent the responses of total populations to alternative operations employed by the coalition administration and forces. This product enables analysts and decision makers to understand the interactions between individual population groups and the aggregate effects of operations.

Impact Measures

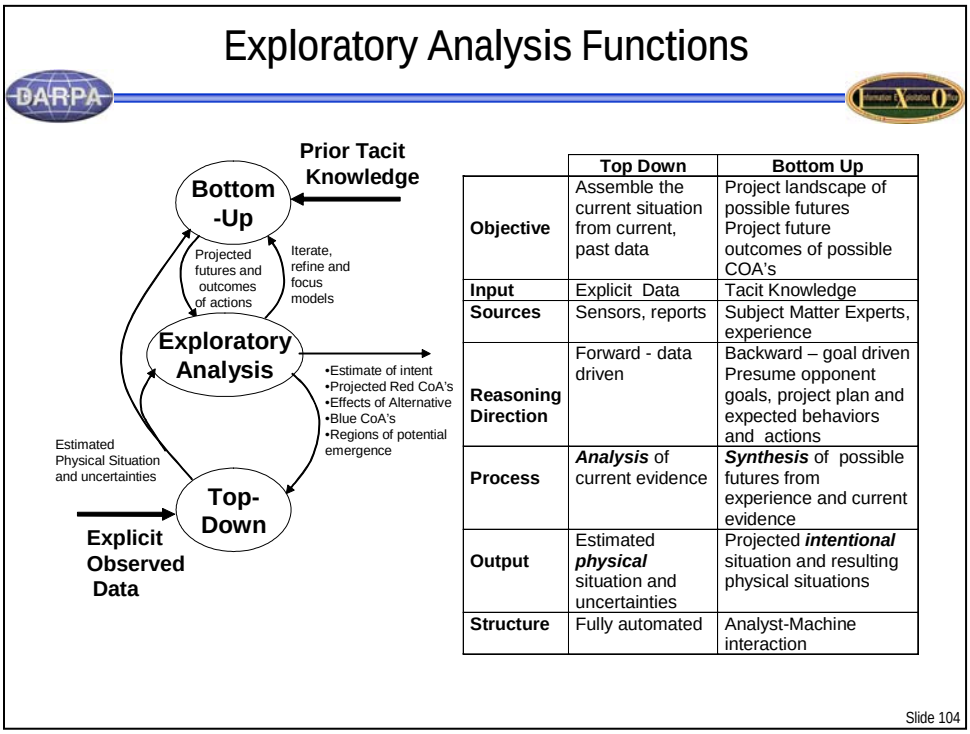
Category	Description	Example Measures
Civil Intelligence Performance Measures	Increased Civil Intelligence	Civil Intel Volume, Timeliness, Accuracy, Depth
		EBO planning predictive accuracy
		EBO options coverage
Operations Impact Effectiveness Measures (Op'l MOE's)	Measures of Cultural Awareness contribution to warning, assessment and operational planning and decision making	PSYOP influence (outcome) measures
		Civil Admin policy (outcome) measures
		IO (outcome) Measures
		Security operations (outcome) measures
		Civil cooperation; Intel participation
Military Mission Utility Measures (Mission MOE's)	High-level Measures of Overall Civil Stability in a AOR or Urban Area	Civil Security (e.g. crime rates)
		Civil Trust and Responsiveness to Civil Affairs (demonstrations)
		Social Health (e.g. refugees, mortality rates)
		Civil Infrastructure and Environmental Quality
		Economic Productivity and Growth (utility availability)
		Political Stability (policy and governance change rate)
		Resistance (Attacks)

The table above enumerates three levels of granularity of measures and the examples of representative measures.

- Civil Intelligence Performance Measure – These detailed performance measures (MOP's) measure the typical information volume, coverage, accuracy, timeliness, and depth parameters of traditional data fusion MOP's. [35]
- Operational Impact Effectiveness Measures – These MOE's measure effects (outcomes) of operations on target populations and systems (e.g. measures of accuracy and rate of civil population intelligence tips to coalition forces and civil security).
- Mission Utility Or Mission MOE's – these measures are the highest level mission MOE's that follow guidance of JP-3-57 Planning Civil-Military Operations: "MOE [Measures of effectiveness] in military operations are defined as tools used to measure results achieved in the overall mission and execution of assigned civil tasks, compared to stated strategic and operational objectives." [36]

[35] Waltz, Edward and Llinas, James, Multisensor Data Fusion, Norwood MA: Artech, 1990, Chapter 11, System Modeling and Performance Measurement

[36] JP-3-57 Planning Civil-Military Operations, *Civil-Military Cooperation in Peace, Emergencies, Crisis and War Page III-10.*



	Top Down	Bottom Up
Objective	Assemble the current situation from current, past data	Project landscape of possible futures Project future outcomes of possible COA's
Input	Explicit Data	Tacit Knowledge
Sources	Sensors, reports	Subject Matter Experts, experience
Reasoning Direction	Forward - data driven	Backward – goal driven Presume opponent goals, project plan and expected behaviors and actions
Process	***Analysis*** of current evidence	***Synthesis*** of possible futures from experience and current evidence
Output	Estimated ***physical*** situation and uncertainties	Projected ***intentional*** situation and resulting physical situations
Structure	Fully automated	Analyst-Machine interaction

One of the significant reasons for the expected gains (and resulting impact on overall mission effectiveness) is due to an improved understanding of the complex population interactions using Urban Sunrise's method of exploratory analysis.

> Exploratory Analysis is defined as those analytic methods that examine the effects of and sensitivities to uncertainty in complex processes. The process integrates top-down analysis and inference from evidence and bottom-up synthesis and simulation from conjecture. (Waltz)

A RAND report on the application of exploratory analysis notes, "The key advantage of exploratory analysis is the ability to model both uncertainty – by using variables to represent things not under decision maker's control – and alternative choices. In using a model, the analyst is forced to organize all thoughts about the problem." [37] The objectives of such analysis are to: 1) understand the implications of uncertainty for the problem at hand, and 2) inform the choice of strategy and subsequent modifications. In particular, *exploratory analysis can help identify strategies that are flexible, adaptive and robust.*[38]

The complex models of human behavior must acknowledge and cope with the uncertainty in the modeling representation itself, as well as in the state of real-world entities modeled.

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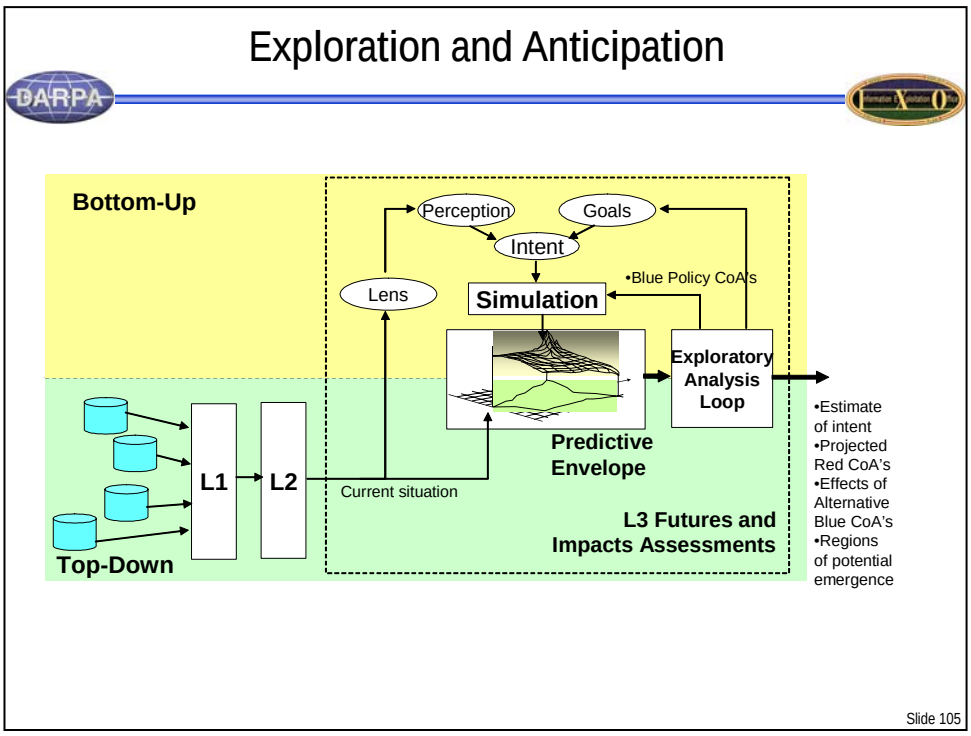
[37] New Challenges, New Tools for Defense Decisionmaking (Stuart Johnson, Martin Libicki, and Gregory F. Treverton, editors), RAND 2003, page 298.
[38] Ibid, page 255.



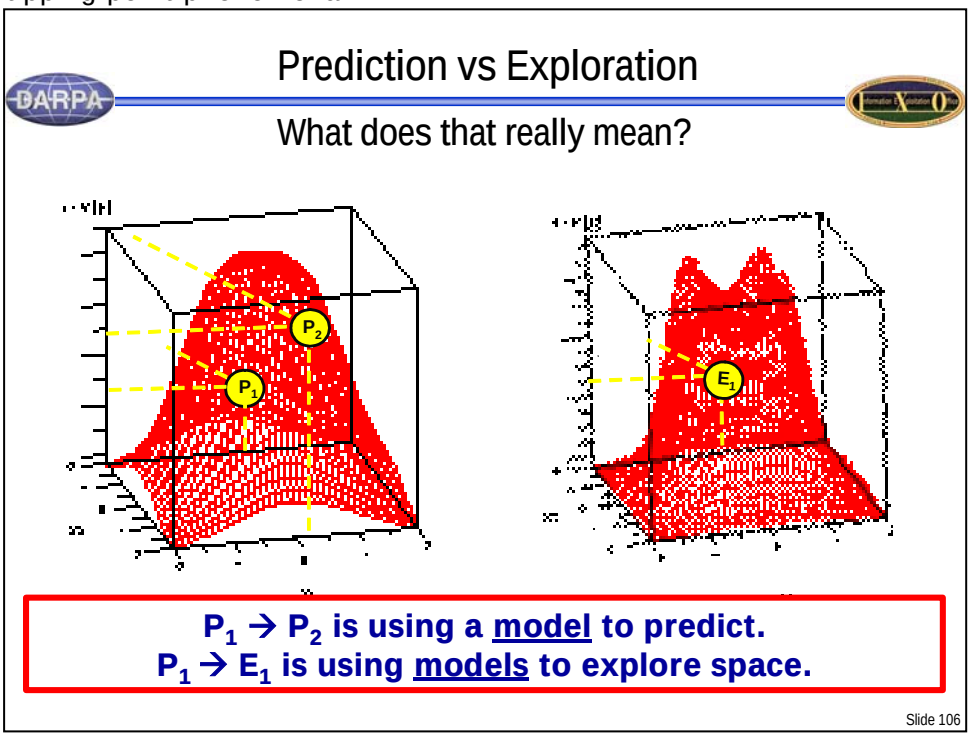
The process to integrate bottom-up (predictive) simulation and top-down (inferential) is illustrated in the figure above, distinguishing two component processes:

Top-Down Inferential Process is essentially analytic – decomposing elements of data to compare to known objects and situations. The process of data fusion correlates and combines evidence (relevant data) at two levels: 1) level 1 correlates and combines evidence on objects of interest (e.g. population entities) and 2) level 2 refines estimates of the aggregates of objects and situations. The product of this process is the estimate of the current urban situation, expressed by a model of the population groups, and the state of the urban information and physical infrastructure.

Bottom-Up Simulation Process is essentially synthetic – synthesizing from interconnected models dynamic simulations of complex behavior representative of feasible real futures based on the current situation (provided by the inferential process) and potential future actions and operations (blue policies). The figure above illustrates how the inferential process is used to set initial conditions for the simulation (current environment and best estimate of target population perception of the situation, viewed through their perceptive lenses).

This process produces a predictive envelope of feasible futures (illustrated as a 3D outcome surface over future time) over a range of possible target goals. The analyst *explores* this envelop of feasible futures to identify emergent (surprising)

consequences, sensitivities to initial conditions and operations and drivers that influence tipping point phenomena.

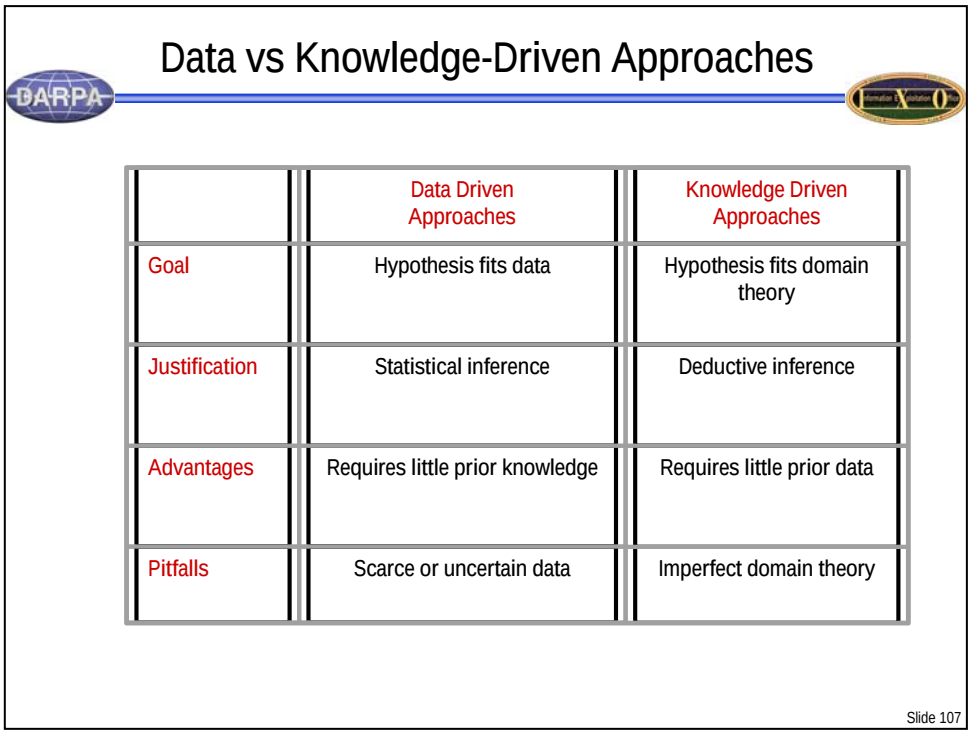


Having established that the fundamental motivation of this study is to explore high-level emergent behavior, this figure attempts to interpret that statement and distinguish our use of the term "explore" from the word "predict". Most models, particularly in the analysis community, are used to generate some form of prediction. That prediction may be an estimate, it may be the identification of a pattern, or it may be the assessment of a plan. Regardless of whether these predictions are precise with a high degree of statistical power or vague guesstimates of future events, the analyst relies on the fact that there is some reasonably well-developed relationship between the model's inputs and outputs. When this confidence exists such that the model is deemed adequate for some purpose, analysts can execute different configurations of that model to generate predictions. This is evidenced in the figure on the left-hand side which shows how changing parameters values of a well-defined model can assist the analyst in making predictions over the model's space.

A noted statistician, George Box, once said that "All models are wrong…some models are useful". Because of the complexity of this problem, models supporting this task as best used in an explorative sense. This is true of agent-based simulations because the behaviors of these models exist only in software and they are difficult to verify through conventional, analytical methods (Riekel, 1995; Ropella, 2002).[39]

[39] It should be recognized that this constraint is not unique to agent-based simulations, but common to all approaches that cannot be supported with statistically verifiable data. See Sickels, S. (2001). Project Scenario Modeling Issues. Technical Report, Veridian Systems; [2] Ropella, G.E.P., Railsback, S.F., and Jackson, S. K. (2002). Software Engineering Considerations for Individual-based Models. *Natural Resource Modeling.* Vol(15), no(1); [3] Rykiel, E. (1995). Testing ecological models: the meaning of validation. *Ecological Modeling. Vol*(90), pp. 229 – 244.

What modelers in this domain must do above and beyond striving for predictive utility, is to strive to develop models that truly allow the exploration of plausible space. This is communicated by combination of figures above that show how the same input vector can result in a variety of different outputs. That is, because the underlying model form is unique, the analyst is truly generating new points in the plausible space. We can achieve this through the use of modeling ensembles, described on the next slide.



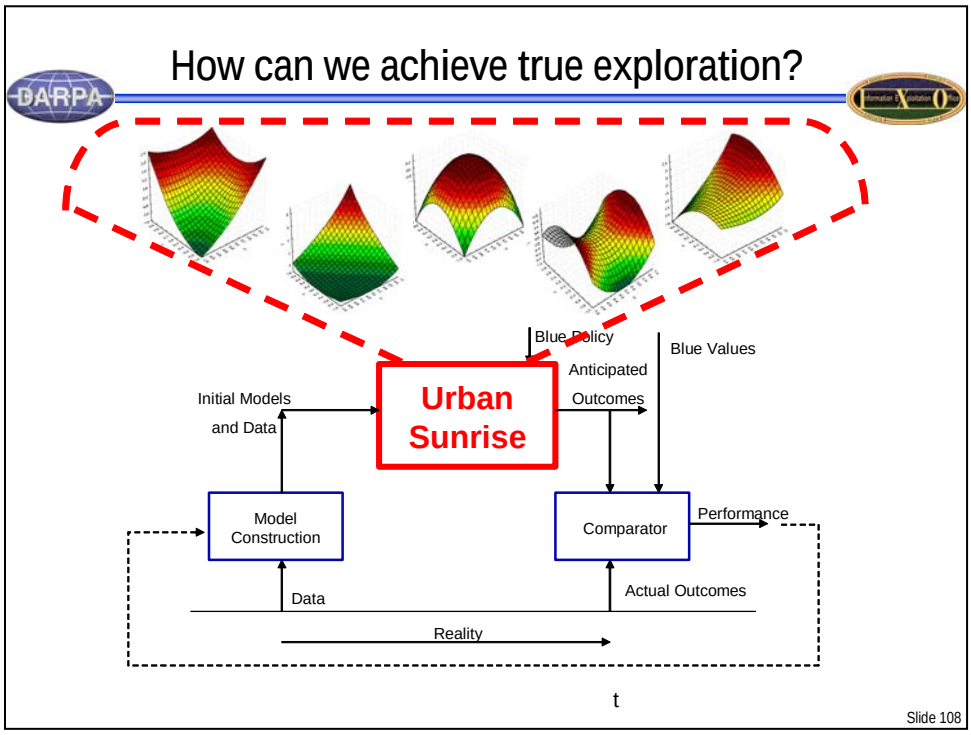
	Data Driven Approaches	Knowledge Driven Approaches
Goal	Hypothesis fits data	Hypothesis fits domain theory
Justification	Statistical inference	Deductive inference
Advantages	Requires little prior knowledge	Requires little prior data
Pitfalls	Scarce or uncertain data	Imperfect domain theory

Because we know of no research that explicitly considers the tradeoffs of human decision making models in C2 or effects-based systems and because research that does exist (on previous slide) is either inconclusive or generalizes to a very small scope, it is not possible for us to know which modeling technique is precisely the best for this task. At best, we are able to draw experientially based tradeoffs between the high-level approaches as they relate. For example, an analytical model may be best suited for a skill-level model, but this type of model is typically harder to integrate with other models that are required to control movement and spatial navigation. On the other hand, AI representation techniques tend to do a better job at this type of integration. The weakness of an AI system, however, is that it might not model the human behavior at a fine-enough level to explain important aspects of that behavior. In this instance, a sub-symbolic cognitive model would probably do a better job. However, these fine-grained, sub-symbolic cognitive models generally do not scale well for representing human behavior in real-time systems.

In the scope of the bigger problem and with respect to other effect-based operations models, we consider the biggest driver behind choice of modeling technology to be the data available to develop the model. Clearly, statistically valid, quantitative data based on history are difficult to generate. And, even if available, using these data to develop the model will result in a model that at best can interpolate or extrapolate what history has already proven. An agent-based approach, on the other hand, is

formed by expert knowledge and opinion. And, while likely less "statistically powerful", this approach does allow analysts to tailor models to a variety of situations and cultures that aren't supported by quantitative, historical data. While these models are still limited to the boundaries of the knowledge base, this space of plausible outcomes is much larger and less constrained than the space generated by classical data-driven models.

Adding to the complexity of the task is the fact that there is currently no universally accepted, comprehensive, validated theory of culture. Clearly, the models of culture proposed in the social-science community are not only complex, but still in their formative stages. This gives rise to a system that is difficult to express in computational terms. And, while there are plenty of anecdotal examples of how culture can affect a battle, we know of no precise data supporting these examples. Further, even if such a database did exist, there is no reason to believe that the data from one conflict could generalize to another. In the best case, a data-driven approach would merely predict based on what's already happened. Thus, the isolated use of mathematical, data heavy tools (e.g., Bayesian methods, neural network based approaches, decision-analytic models, etc) leaves little room for the manifestation of new cultural effects. Agent-based frameworks, on the other hand, can provide for the manifestation of new cultural effects, but they can not be quantifiably validated.



We borrow from idea in neural network and statistical community where predictive utility is optimized by using committees of models.[40] Related concepts that map

[40] C. Bishop (1995). *Neural Networks for Pattern Recognition*, Oxford University Press, Oxford, UK, Section 9, pp.353-368.

onto model are mixtures of experts[41] and ensembles[42], that distinguish between dynamic and static cases.

Generally, ensembles are collections of models that cooperate in performing a prediction. There are a number of uses for ensembles, but we use the concept to explore space by considering predictions across models with different structures, and/or developed from different data sources. This is a relatively simple way to improve generalization. An important piece of theory shows that the expected performance of an ensemble is greater than or equal to the average performance of the individual members.

For this task, one useful approach would be to consider individual deliberations of each model and then offer aggregate statistics on the range of models' output. This would be referred to as an Output Ensemble. Classically, in output ensembles, the ensemble estimates a value for that output by combining the outputs from the individual networks. For classification (nominal outputs), the networks' predictions can be combined in a winner-takes-all vote - the most common class among the combined networks is used. In the event of a tie, the "unknown" class is returned. For regression (numeric variables), the networks' predictions can be averaged. In either case, the vote or average can be weighted using the networks' membership weights in the ensemble (usually all equal to 1.0).

The interactions within and between the cognitive, information, and physical models form the foundation of a model that exhibits emerging behavior. Emergent behavior occurs when a system produces unexpected behavior according to non-linear interactions amongst the system's sub-components. That is, emergence refers to the appearance of higher-level properties and behaviors of a system that are not directly deducible from the lower-level properties of that system[43]. Individual-based models (IBMs) are models that show evidence of emerging behavior in that they are simulations based on the global consequences of local interactions of members of a population. These models can also referred to as entity-based or agent-based models or simulations and they typically consist of an environment or framework in which the interactions occur and some number of entities (e.g., plants and animals in ecosystems, vehicles in traffic, or autonomous characters in animation and games) defined in terms of their behaviors (procedural rules) and characteristic parameters that are tracked through time. In our instance, these entities are organizations.

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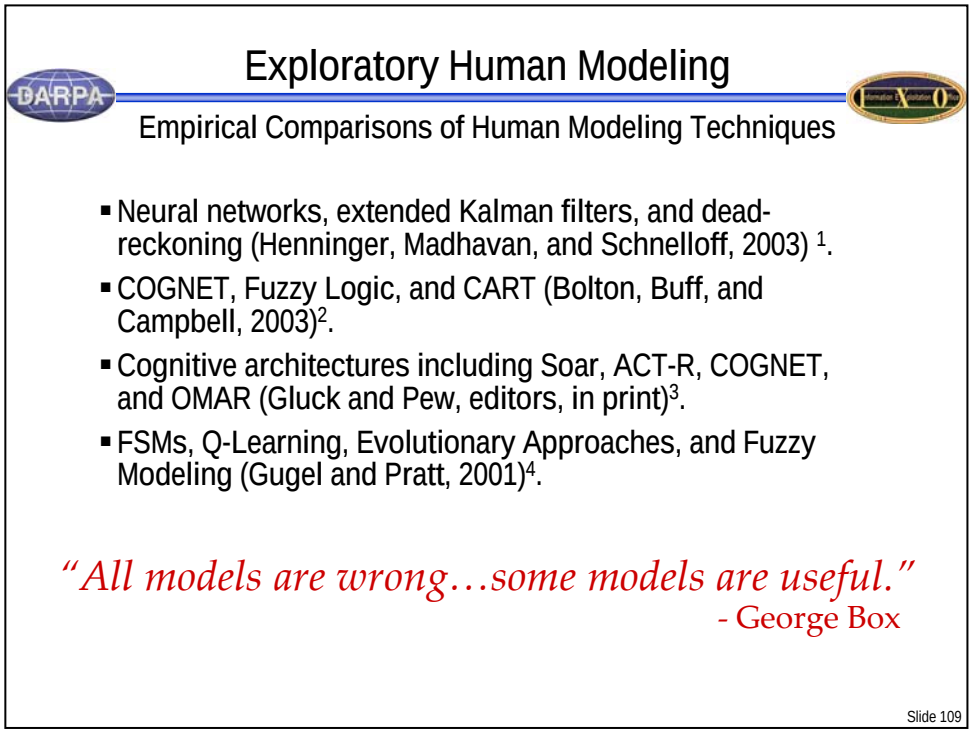
[41] Narendra, K.S., Balakrishnan, J., and Ciliz, M.K. (1995). Adaptation and Learning Using Multiple Models, Switching, and Tuning. Control Systems, vol. 13, no. 3., pp. 37-51.

[42] Murray-Smith, R., and Johansen, T.A. (1997). Multiple Model Approaches to Modelling and Control. Taylor and Francis Inc., Bristol, PA.; and Y. Freund and R.E. Schapire (1996). Experiments with a New Boosting Algorithm, in: *Proc. of 12th Int. Conference on Machine Learning* ICML-96.

[43] Ilachinski, A. (1996a). Land Warfare and Complexity, Part I: Mathematical Background and Technical Sourcebook, Center for Naval Analyses Information Manual CIM-461, July 1996, Unclassified; also Ilachinski, A. (1996b). Land Warfare and Complexity, Part II: An Assessment of the Applicability of Nonlinear Dynamics and Complex Systems Theory to the Study of Land Warfare, Center for Naval Analyses Research Memorandum CRM-68, July 1996, Unclassified.

The model proposed in this investigation makes use of the concept of emerging behavior in two ways. First, the trust model, in isolation is constructed around this concept. That is, the trust experienced by an agent is ultimately the result of a combination of factors (e.g., norms, beliefs, expectancies, perceptions, etc) that interact over time depending on triggers in the scenario. To the extent that these triggers can involve other agents that can be assigned a unique value of trust this becomes another type of emergence. That is, in this latter case, the order of emergence now depends on an additional, higher-ordered set of behaviors emerging from actual entity interaction (as opposed to isolated triggers causing behavior through the interaction of the trust model substructures). Thus, we have a within-agent emerging behavior pattern (i.e., the interaction of the trust model substructures depending on the environment) and a between-agent emerging behavior pattern (i.e., the interaction between agents, both/all of whom can have unique trust values). Taken together, the whole creates a fairly complex feedback system, in which the resulting external behavior would be very difficult to predict analytically. This justifies the approach of building these models within executable intelligent agents, so that the resulting behaviors and effects of trust can be characterized empirically.



Bolton et.al. conducted a study comparing the effectiveness of three HBR modeling techniques (COGNET, fuzzy logic, CART) that vary in their level of cognitive fidelity and development costs at generating useful instruction.[44] Results indicated that all models (mathematical and cognitive-process) led to statistically equivalent improvements in participant performance. Thus, while the cognitive architecture was

[44] Bolton, A., Buff, W., and Campbell, G. (2003). Faster, Cheaper and "Just As Good"? A Comparison of the Instructional Effectiveness of Three HBRs that Vary in Development Requirements**.** *Behavior Representations in Modeling and Simulation Conference*. Phoenix, AZ.

the more costly model to develop, for the very specifically defined task, all models performed equivalently well. Henninger et.al. also compared a variety of models on an extremely well-defined and controlled task.[45] In this instance, however, researchers were able to empirically describe the tradeoffs between using the various approaches. Other attempts to compare human modeling approaches have not yielded usable results, however. In Gluck and Pew, for example, researchers noted differences in theoretical motivations, knowledge encodings, generalization/results, and performance efficiency.[46] One of the weaknesses of this research program, however, was that the task was too open-ended and poorly designed to ascertain meaningful differences. For example, different models were being implemented by different research teams. Thus, the noise from differences in model building approaches made it difficult to parse out differences due to architecture, and an apples-to-apples comparison was not prudent. Finally, in Gugel and Pratt, while models used in comparisons were developed by same researchers, the different principles of the approaches made the specific apples-to-apples comparison impossible for the set of scenarios and metrics explored.[47]

[45] Henninger, A., Madhavan, R., and Schellnoff, C. (2004). Empirical Comparison of Predictive Models for Mobile Agents. To appear in *Knowledge Representation and Ontology for Autonomous Systems: A Symposium at the 2004 AAAI Spring Symposium*, Stanford University, Stanford, CA.

[46] Gluck, K., and Pew, R. (2004), editors. Modeling Human Behavior with Integrated Cognitive Architectures: Comparison, Evaluation, and Validation. In print.

[47] Gugel, A., and Pratt, D. (2001). Implementation Results using Different Behavior Approaches in a CGF Test-Bed. *In Proceedings of the 2001 Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC '01)*.

5. TECHNCIAL ISSUES

Urban Sunrise must tackle a number of challenging technical issues that confront the effort to model and then dynamically simulate the physical, information and cognitive aspects of civil and opposition populations in the urban environment.[48] In addition to the technology development challenges identified in the previous section, four principal top-level challenges are addressed below.

1. Implementing Cognitive-Information-Physical Domain Models – While philosophers have long discussed representations of the physical and metaphysical (cognitive and symbolic "worlds"), practical analytic and computational models of the causal relationships between mental models and the physical world have only recently been attempted. Modeling and simulation of the physical world is readily accepted (e.g. weapon system modeling, kinematic target tracking, and terrain analysis) and command and control models of military information flows have been adopted by the military to analyze network-centric warfare. Only recently has the Defense Modeling and Simulation Office (DMSO) confronted the challenge of modeling human behavior for training and analysis. In a study by the National Academy for DMSO, a framework for implementing human cognitive behavior models has been adopted and the study noted:

> A fundamental problem that faces the human behavior representation community is how to determine which of the many modeling requirements will make a difference in the resultant quality of the models, based on the intended use of the simulation.[49]

We confront this issue in urban Sunrise by: 1) Employing a relatively high-level, general human cognition representation (a goal-directed agent) that includes culturally based influence cognitive factors, and 2) using the simulation to explore a range (or envelope) of behaviors to understand a range effects of operations. A goal of the research is identify the appropriate levels of granularity and fidelity of models in all three domains.

2. Modeling Information Operations and Effects - It is important to recognize that the emphasis of this effort is to model and evaluate the cognitive effects of physical and information operations – therefore this simulation is not a high-fidelity urban war game nor a force-on-force contact simulation. (Such simulations exist, but do not include the crucial cognitive component we are modeling). Effective IO and human decision-making modeling must consider the complexities of culturally relevant rational-irrational behavior, urban denial and deception (D&D) tactics, and the critical interaction of civil populations:

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[48] In this document we adopt the DMSO terminology to distinguish a *model* (a physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process) and a *simulation* (a method for implementing a model over time.)

[49] Richard W. Pew, Anne S. Mavor, (eds.), Modeling Human and Organizational Behavior: Application to Military Simulation, Commission on Behavioral and Social Sciences and Education , National Research Council , Washing ton DC: National Academy Press, 1998, page 17.

> Knowing what groups exist in an urban area, what relationships exist between them, and how each population group will respond to an activity is critical to operational success but often difficult to decipher.[50]

We therefore emphasize the cognitive modeling and aggregate the physical and information domains to a relatively low level of fidelity. In follow-on developments, these domain models may be referenced to the aggregate performance functions derived for higher-fidelity information warfare models of physical and network weapons effects

3. Applying Predictive Intelligence - The recent application of agent based simulation to intelligence and military applications holds great promise to exploratory analysis of complex problems. Yet many question the viability of such predictions that integrate "hard" physical, and "soft" social science models. It is critical, however, to recognize that "predictive intelligence tools" deliver an envelope of anticipated futures – or a likely range of expected and emergent behaviors – rather than point predictions with prophetic accuracy. The URBAN SUNRise capability will provide significant value to the analyst by revealing the emergent and the unexpected – to mitigate the potential for unintended consequences (surprise) and to reveal opportunities to create strategic surprise. It will also contribute value to planners who may evaluate the dynamic effects of information-physical operations. Pioneer of complexity simulation, Robert Axelrod, has wisely noted:

> *The moral of the story is that models that aim to explore fundamental processes should be judged by their fruitfulness, not by their accuracy. For this purpose, realistic representation of many details is unnecessary and even counterproductive. … the intention is to explore fundamental social processes …the interactions of adaptive agents typically lead to nonlinear effects that are not amenable to the deductive tools of formal mathematics.*[51]

4. Validation of Agent-based Simulation – Validation is the process of determining the degree to which a model or simulation is an *accurate representation* of the real world from the perspective of the intended uses of the model or simulation.[52] Validating urban Sunrise simulations pose a significant challenge due to their inherent complexity; we will adopt a method employed in our recent research that includes data validation by subject matter experts first, followed by comparison with representative operational data. We do not expect to achieve validation within the short initial seedling effort, but will plan validation activities in follow-on developments that lead toward operational transition.

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[50] Medby, Jamison J., and Glenn, Russell W., "Street Smart: Intelligence Preparation of the Battlefield for Urban Operations", RAND, MR-1287-A, 2002, page xiii.

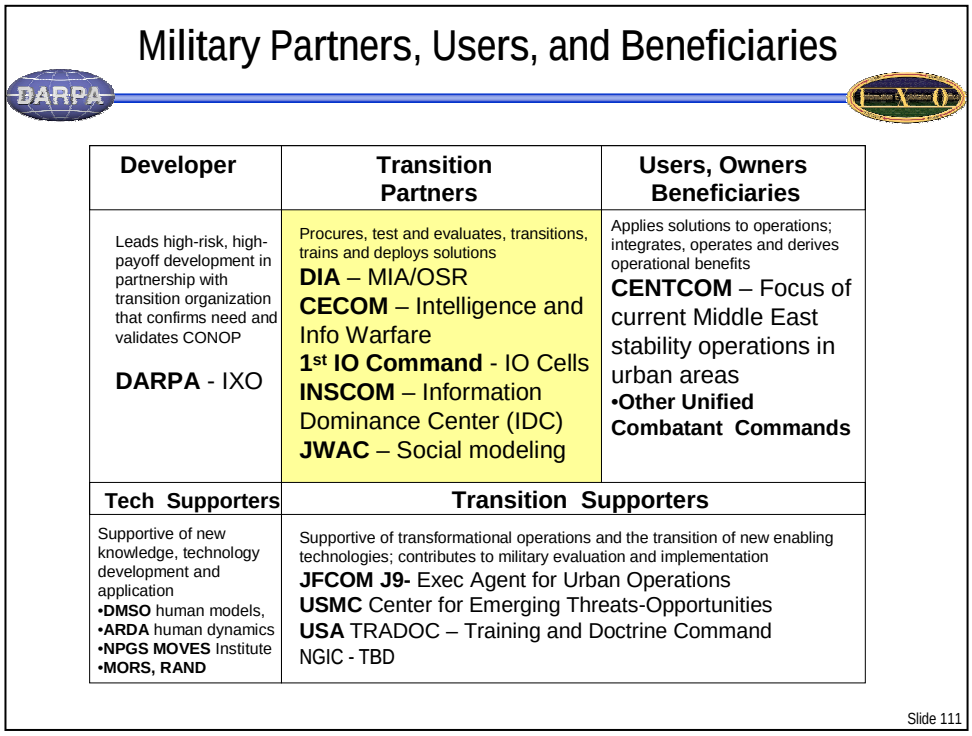
[51] Robert Axelrod, *The Complexity of Cooperation*, Princeton Univ. Press, 1997, page 6.

[52] DoD Directive 5000.59, "DoD Modeling and Simulation (M&S) Management," January 4, 1994.

6. MILITARY TRANSITION

The URBAN SUNRISE study evaluated the potential military and intelligence transition partners, users, and beneficiaries of the capabilities studied. The study distinguished four categories of roles:

- Developers – include DARPA and other organizations supportive of new knowledge, technology development and applications for urban warfighting and peacekeeping missions. These organizations include Defense Modeling and Simulation Office (DMSO) which is researching human representation models, the Advanced Research and Development Activity (ARDA) that has interest in modeling human dynamics, the Naval Post Graduate School MOVES Institute (MOVES is the Modeling, Virtual Environments and Simulation Institute of the Naval Post Graduate School). In addition, the Military Operations Research Society (MORS), and the RAND Corp. are also contributing research in the areas of operations research applied to urban operations.
- Transition Supporters – are supportive of transformational operations and the transition of new enabling technologies; These supporters also contribute to military evaluation and implementation, including: JFCOM J9 (the Exec Agent for Urban Operations and coordinator of Joint Urban Warrior), the USMC Center for Emerging Threats-Opportunities (CETO), and the USA Training and Doctrine Command (TRADOC).



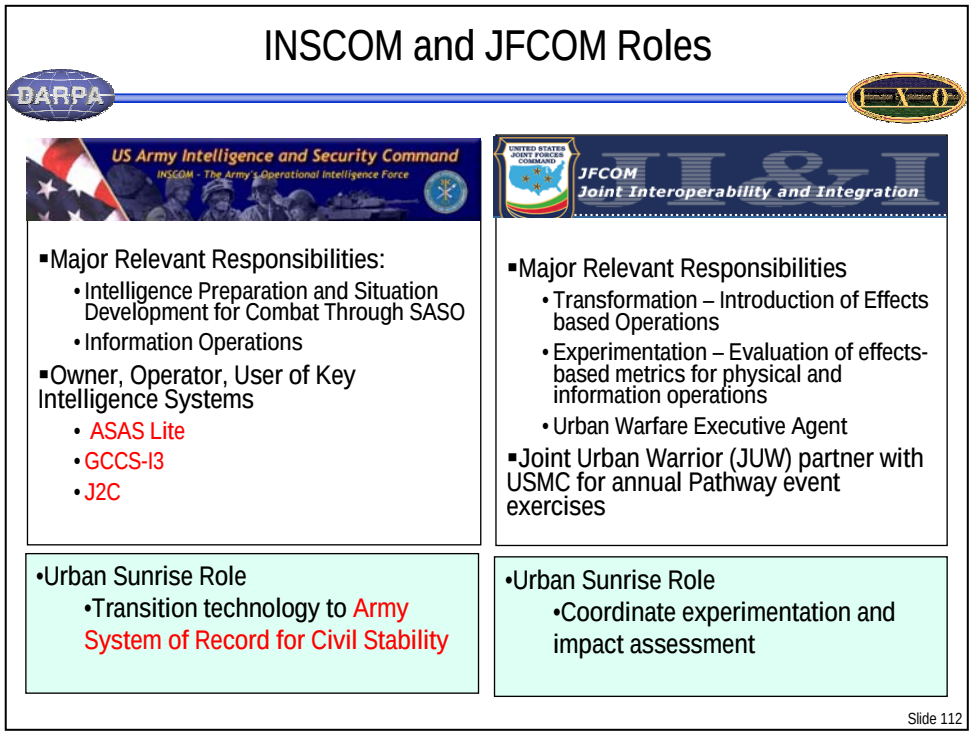
- Users, Owners and Beneficiaries - integrate, operate and derive operational benefits from this new capability. CENTCOM is the focus of current Middle East stability operations in urban areas, and other Unified Combatant Commands will also benefit as potential operational users.

- Transition Partners – are the central organizations that train and deploy solutions and fielded systems that directly fund deployment and maintenance of systems of record. These include:
    - DIA – MIA/OSR
    - CECOM – Intelligence and Info Warfare
    - 1st IO Command - IO Cells
    - INSCOM – Information Dominance Center (IDC)
    - JWAC – Social modeling

The study concluded that the principal transition partners for this capability are INSCOM and JFCOM, with the following respective roles:

INSCOM has major responsibilities for Intelligence Preparation and Situation Development for combat through SASO, and for Army Information Operations. JFCOM is also the Owner, Operator, and user of Key Intelligence Systems of record (e.g. ASAS Lite, GCCS-I3, J2C). As such, it is the appropriate transition partner for transition of urban Sunrise technology to an appropriate system of record.

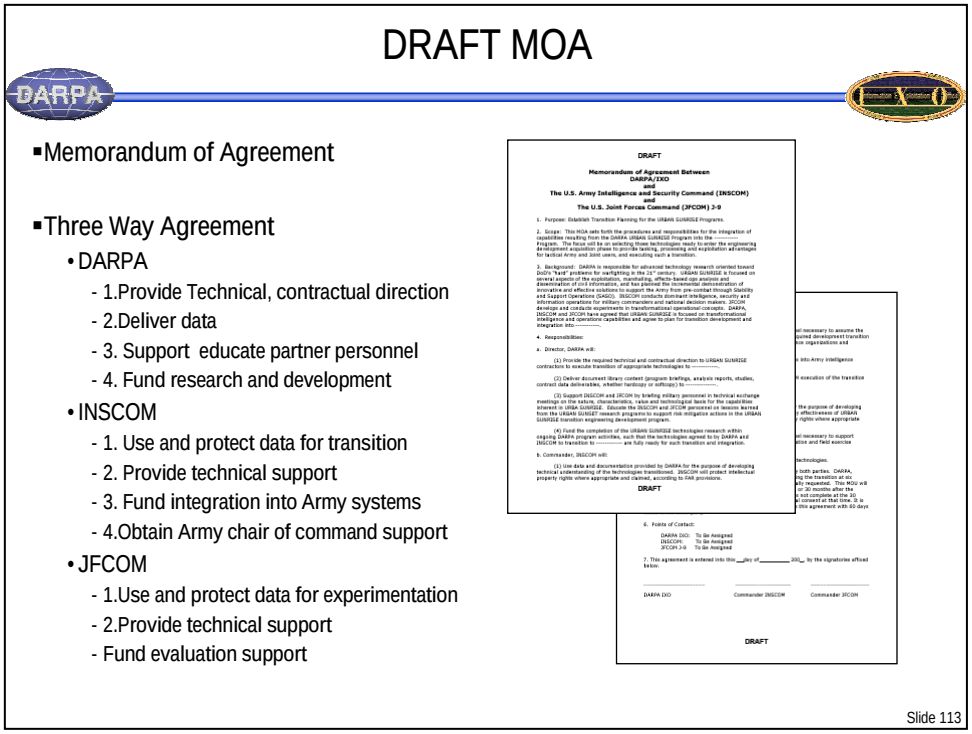
JFCOM has the responsibility for force transformation experimentation, including the introduction of Effects Based Operations. It is responsible for experimentation and the evaluation of effects-based metrics for physical and information operations. JFCOM is the Urban Warfare Executive Agent and conducts the Joint Urban Warrior (JUW) partner with USMC for annual Pathway event exercises.



A Draft Memorandum of Agreement (MOA) is provided in Appendix A of this report to provide a recommended implementation between DARPA, INSCOM and JFCOM.

The MOA is a three way agreement that defines the following roles for each party:

- DARPA
  1. Provide Technical, contractual direction
  2. Deliver data
  3. Support educate partner personnel
  4. Fund research and development
- INSCOM
  1. Use and protect data for transition
  2. Provide technical support
  3. Fund integration into Army systems
  4. Obtain Army chain of command support
- JFCOM
  1. Use and protect data for experimentation
  2. Provide technical support
  3. Fund evaluation support



7. PROGRAM APPROACH

The recommended DARPA program will be conducted in three phases, moving from technology development and incremental evaluation to military transition. The phases are described in the following paragraphs.

Phase 1 Technology Development – The initial phase is a 30-month development of technology in three key areas:

- Foreign Civil Collection
  - Methods for text extraction
  - New passive sensors
  - Active and passive sociological collection
- Intelligence Representation/Fusion
  - Civil ontology development
  - Info extract and Knowledge Base representation
  - Civilian-urban Common Operating picture (COP)
- Ops- EBO Modeling and Simulation
  - Inference net and gent based simulation
  - Info ops (IO) and effects simulation
  - Info and social net models
  - Civil Course of Action (COA) assess tools

The first phase will follow an open DARPA IXO BAA soliciting technology component developments from academia and industry. The multiple contracts will be selected tom ensure coverage of the areas above, management of technology risks, and development of alternative technologies in critical areas.

Phase 2 Spiral Integration and Evaluations – The second phase will integrate technology components into multiple capability demonstrations that will incrementally develop prototype collection, representation/fusion and EBO simulation prototypes. These prototypes will be developed on spiral development cycles with defined performance goals. The achievements in this phase will be related to expected mission effectiveness and utility by JFCOM to assess overall technology contribution and progress.

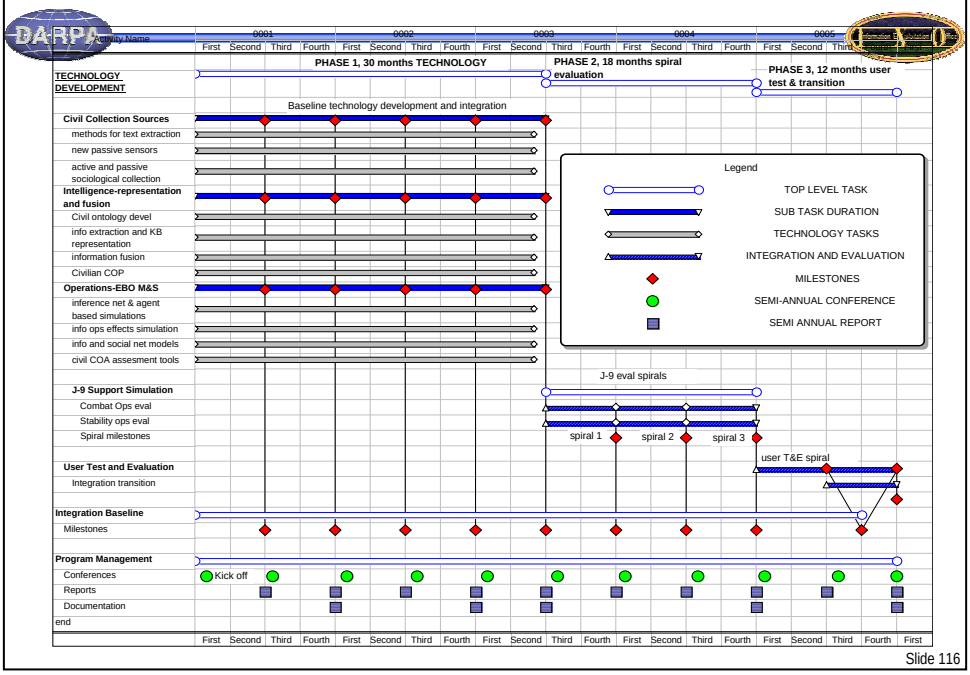
Phase 3 Customer and Transition Partner Test and Evaluation – The third phase is dedicated to test and evaluation of integrated solutions, but testing preparations are initiated in the first two phases to prepare for phase three testing. In Phase 1, contractors will also be required to submit metrics for their products. Integrating contractor will develop integration metrics and an overall test plan for this and subsequent phases. In Phase 2 spiral 1 will use product as developed with training and vendor support as required to meet objectives set by J9. Spiral 2 will have contractor training and minimal support. Spiral 3 will have training and be run by the military. In Phase 3, user/transition partner T&E will be developed with them, but will probably involve a Red Cell CPX, followed by a war game or real world operation, hopefully with software installed on prototype systems of record.

Contractors will be required to submit MOP's for their products as well as functional test plans for the technology they are developing. The integration contractor will write the overall test plan for this and subsequent phases, which will include working with J9 and transition partners. Products will be integrated into the program baseline on 6-month centers, and will undergo integration testing and functional testing as

appropriate. The integration contractor will develop an end of phase test plan that will lead into the J9 evaluation and prove readiness for the spiral phase of user evaluation. Phase 2: is the spiral development phase. The initial phase will evaluate the program software as developed and will directly support the program objectives established with the J9. The first spiral will include contractor training and extensive or as needed contractor support. It is anticipated that the first J9 evaluation will be a Red Team type exercise with Civil play and intelligence derived from real world (probably Iraq) data. The second spiral will again be at the call of the J9, and will include contractor training and minimal, but as required support for the operators. The third phase will again include contractor training from mature training manuals, but the exercise will involve contractor support for trouble shooting only. During this and the subsequent phase, the principal success metrics will involve testimony (I like it, I need it, I want it, It needs improvement), a Likert questionnaire that directly addresses the metrics shown in slide 105 “quantifying the utility and improvements”, and a modified Cooper-Harper HQRS evaluation for specific sub tasks.

Phase 3: is the Test and Evaluation phase with the user community and the transition partner. During phase 1, and iterated in conjunction with the user community, a final test plan will be developed by the integration contractor. Normally, the user community increases user involvement as a function of system maturity which is proven through a series of evaluations. The user community will have seen the J9 tests, and may opt for a CPX (command post exercise) followed by a limited field evaluation, and finally a real world evaluation. The intention is to have prototype transition systems be used with the evolved CONOP. As in phase 2, testimony by the users, a Likert questionnaire, and a modified Cooper-Harper HQRS for specific sub tasks will be used to create success metrics. The critical metric will be whether the service will adopt the system and make it part of their war fighting baseline.

Schedule



Slide 116

The overall schedule (above) and accomplishments (below) are organized to provide aggressive, early technology development toward a specific technology integration plan with measurable performance and effectiveness goals to measure progress at each technology delivery and at each of the phase 2 development spirals.

Program Phase Accomplishments

Results	Phase II Spiral Evaluation	Phase III Test
Delivered Demonstration	Proof of Concept (POC) Demonstrator analytic tool and preliminary CONOPS methodology	Operational prototype evaluation suitable for subsequent network integration into operational INSCOM systems
Test Subject	Synthetic medium resolution fidelity urban area based on open source intelligence (Unclassified)	Exercise urban area in Joint Urban Warrior (JUW) , or other Joint Exercises (Classified or unclassified)
Capabilities Delivered	Unclassified demonstrations of component technologies in three areas.	Classified demonstration of integrated collection, fusion, planning and dissemination. Integrated with operational NIMA, INSCOM and DIA data sources.
CONOPS	Initial operational concept for coordinated info ops (IO) and physical ops simulation applied to the demo urban area. Initial IPB Knowledge base of urban characteristics for physical and info ops.	Coordinated initial CONOPS developed with transition military intelligence and operations users. CONOPS will include integrated simulation of physical and information operations to support Effects Based Operations (EBO) doctrine for joint forces.
Impact Measures Verified	Measures of performance (MOP's) of component technologies. Comparison to current capabilities.	Measures of EBO effectiveness; Measures of Effectiveness (MOE's) assessment by intelligence and ops personnel in military exercises.
Transition Activities	Review component technology demonstrations and integration progress; assess readiness Refine and Approve Phase III Test Plan	Coordination of evaluation exercises (ApEX) and pre-deployment testing Prepare for transition to program-of-record Conduct Exercise training Document Exercise Lessons Learned.

Slide 117

8. SUMMARY

As evidenced in current operations in the Balkans, Afghanistan and Iraq, there exists a critical need for foreign civil intelligence collection, fusion and civil effects-based ops modeling and simulation to support urban combat and stability operations. This need has been articulated by the Joint Staff, the Defense Science Board and the military services as cited in this report. URBAN SUNRISE will provide civil behavior representation, fusion and predictive EBO is as high-risk, high-payoff venture, suitable for DARPA investment. INSCOM and JFCOM are suitable transition partners, eager to receive and apply the capability.

9. REFERENCES

The following references have been acquired by the Urban Sunrise team for a relevant technical library and have been used in the preparation of this report.

Urban Warfare and Civil Populations

Global Trends 2015: A Dialogue about the Future with Nongovernment Experts, U.S. National Intelligence Council, December 2000, Section 5, “Population Trends”.

Medby, Jamison J., and Glenn, Russell W., “Street Smart: Intelligence Preparation of the Battlefield for Urban Operations”, RAND, MR-1287-A, 2002.

Mordica, George, Dismounted Close Combat Conference, Urban Operations Lessons Learned, Center for Army Lessons Learned (CALL), January 2003

MOUT ACDT Overview briefing, 9 May 2002.

Urban Operations in the Year 2020, NATO Study Final Report , Study Director, Col. Philip Baxter, UK MOD, 23 May 2002.

Sinai, Joshua, Red Teaming the Terrorist Threat to Preempt the Next Waves of Catastrophic Terrorism, ANSER, Proc. 14th Annual NDIA SO/LIC Symposium & Exhibition, 12 February 2003.

Trahan James R . (Major USMC), The Influence of Culture on Post Cold War Military Operations: An Examination of the Need for Cultural Literacy, CSC 1995, Marine Corp Univ. Command and Staff College, 1995.

Wattenbarger, Frank, Technologies for the Global War on Terror, Advanced Technology SOCOM, 13 February 2003.

Relevant Joint Publications and Field Manuals

Joint Pub 3-06, Doctrine for Joint Urban Operations, Joint Chiefs of Staff, (16 September 2002).

Joint Pub 3-13 "Joint Doctrine for Information Operations", (9 October 1998).

Joint Pub 3-07.3 Joint Tactics, Techniques, and Procedures for Peace Operations (12 Feb 1999)

Joint Pub 5.00-1 Joint Doctrine for Campaign Planning (25 Jan 2002)

FM 3.06-11 Combined Arms Operations in Urban Terrain (2000)

FM 3-06 Urban Operations; Appendix B, Urban IPB

FM 3-07 Stability Operations and Support Operations (February 2003)

FM 27-100 Legal Support to Operations (1 March 2000)

FM 34-36 Special Operations Forces Intelligence and Electronic Warfare Operations (30 Sept 1991)

FM 34-130 Intelligence Preparation of the Battlefield (8 July 1994)

FM 100-5, Operations (14 June 1993)

FM 100-23 Peace Operations (30 December 1994)

Urban IPB, Intelligence Analysis and Operations Planning

FM 3-06 Urban Operations; Appendix B, Urban IPB

Dilegge, David P., Urban Analysis – A Need at All Levels of Operation and Command and Particularly for Marine Expeditionary Forces, The Urban Operations Journal, 2002.

Dilegge, David P., Wargaming and Analyzing the Urban Threat, URBAN COMBAT OPERATIONS, NEWSLETTER NO. 99-16

Smyth, Ted, "Summation of the Analysis of Urban Warfare Workshop, Phalanx, Military Operations Research Society, Vol. 34, No. 4, December 2001.

JP 3-13 Joint Doctrine for Information Operations, JCS, 9 October 1998.

Joint Information Operations Planning Handbook, Joint Command and Control and Information Warfare School, Joint Forces Staff College, July 2003.

Salvucci, Dario D., Siedlecki ,Timothy, Toward a Unified Framework for Tracking Cognitive Processes, Department of Computer Science, Drexel University, May 2003

Crino, Scott T, Representation of Urban Operations in Military Models and Simulations, in Proceedings of the 2001 Winter Simulation Conference, B. A. Peters, J. S. Smith, D. J. Medeiros, and M. W. Rohrer, (eds)

Hartley D. S. III, OPERATIONS OTHER THAN WAR: REQUIREMENTS FOR ANALYSIS TOOLS RESEARCH REPORT, K/DSRD-2098, Prepared for PACOM J53, DOE Project No. 2127-G104-A1, December 1996.

Effects Based Operations Analysis and Planning

Davis, Paul K., Effects Based Operations (EBO): A Grand Challenge for the Analytic Community, MORS Annual Meeting, June 2001.

Saunders-Newton, Desmond and Aaron B. Frank "Effects-Based Operations: Building the Analytic Tools", Defense Horizons, Washington DC: National Defense University, October 2002.

Wagenhals, Lee W., Effects based Course of Action Analysis in Support of Wargames, MORS Workshop on Analyzing Effects Based Operations, January 20, 2002.

Smith, Edward R., Effects based Operations: applying network Centric warfare in Peace, Crisis and War, CCRP, Nov. 2002

Senglaub, Michael, The Analytic and Philosophical Imperatives of Effects Based Operations, Sandia national lab, January 2002.

Kessler, Graham, Effects Based Operations, JFCOM J-9, Nov. 2002.

Modeling and Simulation of Human Behavior

Adams, B. D. and R. D. G. Webb (2002). Trust in Small Military Teams. 7th ICCRTS, Québec.

Axelrod, R. (1997). The Complexity of Cooperation: Agent-based Models of Competition and Collaboration. Princeton, NJ, Princeton University Press

Bellifemine, F., Poggi, A., Rimassa, G. JADE – A FIPA-compliant agent framework Proceedings of PAAM'99, London, April 1999, pgs 97-108. http://jade.cselt.it/

Bonabeau, Eric, "Predicting the Unpredictable", Harvard Business Review, March 2002, pp. 109-116.

Bonabeau, E., Dorigo, M., and Theraulaz, G. (1999) *Swarm Intelligence: From Natural to Artificial Systems*. Oxford University Press: New York.

Dasgupta, P. (1988). Trust as a Commodity. Trust: Making and Breaking Cooperative Relations. D. Gambetta. Oxford, Basil Blackwell**:** 49-71

Doney, P. M., J. P. Cannon and M. R. Mullen (1998). "Understanding the Influence of National Culture on the Development of Trust." Academy of Management Review **23**(3): 601-620

Epstein, J. M. and Axtell, R. (1996) *Growing Artificial Societies - Social Science from the Bottom Up*. MIT Press: Cambridge, MA.

Florin, J. (1996). A Cognitive Explanation for the Influence of Culture on Strategic Choice in International Business. Eastern Academy of Management Meeting, Washington, DC.

Franke, R. H., G. Hofstede and M. H. Bond (1991). "Cultural Roots of Economic Performance: A Research Note." Strategic Management Journal **12**: 165-173.

Gardner, M. (1970) “The fantastic combinations of John Conway’s new solitaire game ‘life’.” *Scientific American*: 223. October. pgs 120-123.

Henninger, Amy E. (SoarTech), Randolph M. Jones, Eric Chown, “Behaviors that Emerge from Emotion and Cognition: A First Evaluation”, 2002*, Proc. of Interservice/Industry Training Systems and Education Conference (I/ITSEC) -42 December 2002.* Newell, A., Unified Theories of Cognition. Cambridge, MA, 1990.

Howden, N., Ronnquist, R., Hodgson, A., Lucas, A. (2001) JACK Intelligent Agents – Summary of an Agent Infrastructure. 5th International Conference on Autonomous Agents.

Huff, L. and L. Kelley (1999). Trust Formation in Collectivist and Individualist Societies. 8th Cross-Cultural Consumer and Business Studies Conference, Cancun, MX

Karjoth, G., Lange, D., Oshma, M. (1997), A Security model for Aglests, IEEE Internet Computing, Vol. 1, No. 4, July/August .1997

Laird, J. E., A. Newell and P. S. Rosenbloom (1987). "Soar: An architecture for general intelligence." *Artificial Intelligence* 33(3): 1-64.

Langton, C., Burkhart, R., and Ropella, G. (1997) The Swarm Simulation System. http://www.swarm.org

Lundgren, H. and R. Walczuch (2003). "Moderated Trust - The Impact of Power Distance and Uncertainty Avoidance on the Consumer Trust Formation Process in E-Retailing." unpublished manuscript

Marsh, S. (1994). Formalizing Trust as a Computational Concept. Department of Computing Science adn Mathematics. Sterling, University of Sterling**:** 184

McKnight, D. and N. Chervany (2001). Trust and Distrust Definitions: One Bite at a Time. Trust in Cyber-societies. R. Falcone, M. Singh and Y.-H. Tan. Berlin, Springer-Verlag

Pew, Richard W., Anne S. Mavor, (eds.), Modeling Human and Organizational Behavior: Application to Military Simulation, Commission on Behavioral and Social Sciences and Education , National Research Council , Washing ton DC: National Academy Press, 1998.

Prietula, M. (2001). Advice, Trust, and Gossip Among Artificial Agents. Dynamics of Organizations: Computational Modeling and Organizational Theories. A. Lomi and E. Larson. Cambridge, MA, MIT Press

Prietula, M. and K. Carley (1998). A Computational Model of Trust and Rumor. AAAI Fall Symposium Series - Emotional and Intelligent: The Tangled Knot of Cognition, Orlando, FL.

Taylor, Glenn, Randolph M. Jones, Michael Goldstein, Richard Frederiksen, Robert E. Wray, III, "VISTA: A Generic Toolkit for Visualizing Agent Behavior", *Proc. 11th CGF-BR Conference 7 May 2002.*

Waltz, Ed "Employing Data Fusion Tools within Intelligence Community Analysis (U)" in *Proc. of 14th National Symposium on Sensor and Data Fusion*, August 2002.

Waltz, Ed, "Data Fusion in Offensive and Defensive Information Operations", in Proc. of 12th National Symposium on Sensor and Data Fusion, June 2000.

Waltz, Ed, Data Fusion Conceptualization, Specification and Information Operations, in Proc. of DARPA Ontology and Visualization Workshop, Buffalo NY, November 18-22, 2002, accessed online 1 February 2003 at Workshop website <http://www.infofusion.buffalo.edu/index.html>.

Wray, Robert E. (SoarTech), Randolph M. Jones (SoarTech), John E. Laird and Andrew Nuxoll, "Intelligent Opponents for Virtual Reality Trainers", Proc. of *2002 Interservice/Industry Training Systems and Education Conference (I/ITSEC) 2-4 December 2002.*

APPENDIX A

DRAFT Memorandum of Agreement Between DARPA/IXO and The U.S. Army Intelligence and Security Command (INSCOM) and The U.S. Joint Forces Command (JFCOM) J-9

1. Purpose: Establish Transition Planning for the URBAN SUNRISE Programs.

2. Scope: This MOA sets forth the procedures and responsibilities for the integration of capabilities resulting from the DARPA URBAN SUNRISE Program into the ---------- Program. The focus will be on selecting those technologies ready to enter the engineering development acquisition phase to provide tasking, processing and exploitation advantages for tactical Army and Joint users, and executing such a transition.

3. Background: DARPA is responsible for advanced technology research oriented toward DoD's "hard" problems for warfighting in the 21st century. URBAN SUNRISE is focused on several aspects of the exploitation, marshalling, effects-based ops analysis and dissemination of civil information, and has planned the incremental demonstration of innovative and effective solutions to support the Army from pre-combat through Stability and Support Operations (SASO). INSCOM conducts dominant intelligence, security and information operations for military commanders and national decision makers. JFCOM develops and conducts experiments in transformational operational concepts. DARPA, INSCOM and JFCOM have agreed that URBAN SUNRISE is focused on transformational intelligence and operations capabilities and agree to plan for transition development and integration into ----------.

4. Responsibilities:

a. Director, DARPA will:

(1) Provide the required technical and contractual direction to URBAN SUNRISE contractors to execute transition of appropriate technologies to ----------.

(2) Deliver document library content (program briefings, analysis reports, studies, contract data deliverables, whether hardcopy or softcopy) to ----------.

(3) Support INSCOM and JFCOM by briefing military personnel in technical exchange meetings on the nature, characteristics, value and technological basis for the capabilities inherent in URBA SUNRISE. Educate the INSCOM and JFCOM personnel on lessons learned from the URBAN SUNSET research programs to support risk mitigation actions in the URBAN SUNRISE transition engineering development program.

(4) Fund the completion of the URBAN SUNRISE technologies research within ongoing DARPA program activities, such that the technologies agreed to by DARPA and INSCOM to transition to ---------- are fully ready for such transition and integration.

b. Commander, INSCOM will:

(1) Use data and documentation provided by DARPA for the purpose of developing technical understanding of the technologies transitioned. INSCOM will protect intellectual property rights where appropriate and claimed, according to FAR provisions.

(2) Provide the technical support and proficient personnel necessary to assume the responsibility for the completion of technology research and required development transition for URBAN SUNRISE technology integration into Army intelligence organizations and systems.

(3) Fund the integration of URBAN SURISE technologies into Army intelligence organizations and systems.

(4) Obtain Army chain of command support for INSCOM execution of the transition efforts.

c. Commander, JFCOM will:

(1) Use data and documentation provided by DARPA for the purpose of developing experimentation plans to evaluate the performance and military effectiveness of URBAN SUNRISE technologies. JFCOM will protect intellectual property rights where appropriate and claimed, according to FAR provisions.

(2) Provide the technical support and proficient personnel necessary to support planned evaluations of URBAN SUNRISE technologies by simulation and field exercise activities.

(3) Fund the evaluation support for f URBAN SUNRISE technologies.

5. Period of Agreement: This MOA is effective upon signing by both parties. DARPA, INSCOM and JFCOM leadership will review progress in completing the transition at six month intervals until completion, or more frequently if specifically requested. This MOU will remain in effect until all parties mutually agree to terminate it, or 30 months after the signature date, whichever comes first. If the transition effort is not complete at the 30 month point, both parties may extend the agreement by mutual consent at that time. It is further agreed and understood that either party may terminate this agreement with 60 days notice to the other party.

6. Points of Contact:

DARPA IXO: To Be Assigned
INSCOM: To Be Assigned
JFCOM J-9 To Be Assigned

7. This agreement is entered into this ___day of _____ 200_, by the signatories affixed below.

_____ _____ _____

DARPA IXO Commander INSCOM Commander JFCOM

APPENDIX B

Survey of the Use of the Term Culture in Military Operations

Glenn Taylor
glenn@soartech.com
Revised 30 October 2003

"… the lesson learned [in Somalia] that kept coming out was that we lacked cultural awareness. We needed cultural intelligence going in."
Gen Anthony Zinni (USMC Ret.)
National Defense University
August 8, 1996

This document is an attempt to define the term *culture* as it relates to military operations. There are a few perspectives on culture, of course; many of them are incompatible, and some are more useful than others. The military has used the term culture in many different ways over the last decade or so, as its operations have become more placed in regions where civilians are more of an obstacle. This document includes a survey of military documents over the last several years in an attempt give a sense of the varied use of culture, and the limitations of those uses.

Culture in Military Operations
The term culture, as it appears in common use, centers on society:

"The totality of socially transmitted behavior patterns, arts, beliefs, institutions, and all other products of human work and thought."
The American Heritage® Dictionary of the English Language, Fourth Edition

Generally, we think of cultural on a national scale, though it is not the only type. Uses of culture include terms like *corporate culture* or *military culture* implies the use of culture for smaller segments of a society, including functional organizations or regional variations. Furthermore, an individual is typically part of multiple cultural groups simultaneously, defined by region, occupation, interests, etc. For example, a person could be part of a country (the US), a region (the North), an industry (information technology) and a company (IBM). Each of these organizational groups represents a different culture, and recent research suggests ways in which these multiple cultures affect behavior in the same individual ((Franke et al. 1991); (Florin 1996)). A model of culture will inevitably have to take into account these different cultures and their interplay.

Military conflict has very often been a conflict of cultures; that is, conflict is (partly) rooted in the differences between cultures. This is especially true in ethnic conflicts. As modern military conflict has moved away from large-scale, high-intensity (RAND) wars to smaller-scale, more regional confrontations, with more face-to-face interactions in post-war transitions or military operations other than war (MOOTW), the differences between cultures become more apparent, and cultural factors as a whole become more important in the outcomes of these engagements.

The term *military culture* is somewhat compelling in this arena. In multi-national coalitions, differences in military cultures (and, of course, national cultures) between participating members of the coalition must be understood in order for the team to work well together as a whole. This is an area that is only recently receiving attention, and problems are still evident in groups such as the UN, SFOR in Bosnia, etc. The US military has event felt the effects of cultural differences internally as it adopts a "joint culture" for operations: the different services branches have their own, sometimes incompatible, cultures.

Culture has begun to receive some attention in military doctrine. In these documents, culture often includes common elements such as beliefs, values, and religion, but also physical elements such as buildings and infrastructure. Often, culture is referred to in the context of "cultural awareness." Special Operations Forces are trained in the cultural aspects of their area of responsibility, including the "cultural, historical, political, economic, and security issues of a particular region."(REF) In fact, Special Operations Forces seem to be the most exposed to cultural aspects of a region of interest. In the conventional forces, military linguists often bear the torch as subject matter experts in the culture of a region. (http://wrc.lingnet.org/culmil.htm)

The military has also used the fairly common map term "cultural features", which represent man-made artifacts of a terrain and their representations on maps. (A glib view is that cultural features are all the man-made things that get in the way of tanks.)

To convey a sense of the treatment of culture in the military, what follows is a survey of military documents that mention or consider culture, cultural intelligence, or cultural awareness.

FM 3.06-11 Combined Arms Operations in Urban Terrain (2000)

Appendix G: Intelligence Requirements Checklists for Urban Operations

Section 1. Cultural Intelligence Requirements

In this document, culture is loosely defined as "the social fabric of a city."

- Cultural Norms – " food, sleep patterns, casual and close relationships, manners, and cleanliness"
- Religious Beliefs
- Local Government – "may include nepotism, favor-trading, subtle sabotage, and indifference"; "corruption is sometimes pervasive and institutionalized"; "power of officials is primarily based on family connections, personal power base, and age, and only after that on educations, training, and competence."
- Local Population – will behave in their own self-interest; keenly aware of four interests: US forces, hostiles, local opportunists, general population
- Refugees – rural and urban displacements that can cause severe strategic problem

Intelligence requirements include aspects of the population and urban social structure.

Section 2 details the city infrastructure and services, so these are not explicitly listed as cultural features. These would include transportation, physical composition, utilities, airfields, etc.

FM 100-5, Operations (14 June 1993)
Chapter 5 Combined Operations

"Each partner in combined operations possesses a unique cultural identity, the result of language, values, religious systems, and economic and social outlooks. Nations with similar cultures are more likely to have similar aspirations. Further, their armed forces will face fewer obstacles to interoperability in a combined force structure. Nations with divergent cultural outlooks have to overcome greater obstacles in a coalition or alliance. Armies reflect the national cultures that influence the way they operate. Sources of national pride and cultural sensitivities will vary widely, yet the combined force commander must accommodate them. Differences in work ethic, standards of living, religion, and discipline affect the way nations approach war. Commanders cannot ignore these differences because they represent potential major problems. Even seemingly minor differences, such as dietary restrictions or officer/soldier relationships, can have great impact. Commanders may have to accommodate religious holidays, prayer calls, and other unique cultural traditions that are important to allies." (p. 5-2)

FM 100-23 Peace Operations (30 December 1994)

"The analysis [of the local area] includes...ethnic backgrounds, languages, and religious beliefs; tribe, clan, and subclan loyalties;...holiday and religious observances practiced by the local populace." (FM 100-23, Peace Operations, p. 46.)

"All personnel involved in peace operations must receive training on the customs of the local population and coalition partners." (FM 100-23, p. 88.)

FM 34-130 Intelligence Preparation of the Battlefield (8 July 1994)
Chapter 6: Intelligence Preparations of the Battlefield for Operations Other than War

The rest of this document primarily considers friendlies and threats, and no one else. Chapter 6 is really the only section that deals with aspects of cultural intelligence, though it isn't named as such. As part of Humanitarian Assistance and Peacekeeping Operations, and Peace Enforcement, some cultural aspects are considered:

- Population distribution patters
- Ethnic divisions
- Religious beliefs
- Language divisions
- Tribe, clan, and sub-clan loyalties
- Political sympathies
- Demographics:
    - Roots of conflict
    - Belligerents
    - Trust

- Outside influence: organizations, media

FM 34-36 Special Operations Forces Intelligence and Electronic Warfare Operations (30 Sept 1991)

Chapter 10: Intelligence Preparation of the Battlefield for Special Operations Forces

Without actually using the some of the terms we are adopting, this document describes intelligence requirements relevant to our discussion of cultural intelligence. In addition to the normal structural and infrastructural aspects of the area of interest, the battle area evaluation (BAE) for SOFs includes:

- Political
- Military
- Economic
- Social
- Geographic
- Psychological
- Cultural
- Friendly Forces
- Hostile Forces
- Nonbelligerent third-party forces

For PsyOp, the BAE includes other cultural features:

- Ethnic, racial, social, economic, religious, linguistic groups: locations and densities
- Stances of groups: pro-gov, neutral, pro-insurgent
- Key leaders and communicators: politicians/government and business/clergy
- Cohesive and divisive issues within community (e.g., attitudes toward US)
- Literacy rates, education levels
- Types and proportions of media consumed by community
- Concentrations of 3rd country nationals in area: purpose and function

Additionally, some of this information is represented as part of a Population Status Overlay on a map. This includes the information above, and may include home and workplaces of key players and their relatives. This map overlay may be cross-referenced to personality, faction, and organization files. (Other overlays, including the Lines of Communication Overlay, would be very important as part of a planning tool.) Population Analysis (as part of Terrain or Geographic Analysis) considers the following:

Table 1 : Population analysis factors in the SOF IPB

Social organizations	Density and distribution of population by groups; balance between urban and rural; race, religion, origin, tribe, class, political party, unions, occupation, etc; overlaps among and splits between groups; composite groups; active or potential motivating issues
Economic organizations	Major ideologies; infrastructure; national economic performance; production performance; public health; trade patterns; education programs; employment patterns; revenues; population dispersal patterns
Political organizations	Formal political structure and sources of power; informal political structure; legal and illegal political parties; non-party political organizations and motivations; nonpolitical interest groups (churches, unions) and correlations with other organizations; mechanisms for government successions; independence, subordination, and effectiveness of judiciary; independence or control of press/mass media; centralization or diffusion of decision making; administrative competence
History of the society	Origin of incumbent government; history of political violence
Nature of the threat	External national support; desired goals and plans; internal group support; discord within; organization structures and patters; stage and phase of threat; unity and disagreement within and without; exploitable vulnerabilities and weaknesses
Nature of the government response	General planning for countering threat; organization and methods for planning and execution; population and resources utilization; security forces; population and resource control measures; economic development programs
Effects on nonbelligerents	Mechanisms for monitoring attitudes and responses; common objectives; effects of government/poli/econ/social operations on populace; whether

	populace inclined to provide threat/gov't with intelligence
COA of the threat, government, and nonbelligerent	Likely COAs for each group

Joint Pub 5.00-1 Joint Doctrine for Campaign Planning (25 Jan 2002)

Cultural Intelligence mentioned as part of the Intelligent Preparation of the Battlespace (IPB) (or Operational Environment Research (OER)):

From a procedural perspective, the analysis of the adversary's COGs is a key step in the **joint intelligence preparation of the battlespace (JIPB) process**. In the third of four steps in the JIPB process, **joint force intelligence analysts identify adversary COG**s. The analysis is conducted after an understanding of the broad operational environment has been obtained and before a detailed study of the adversary's forces occurs. **The analysis addresses the adversary leadership, fielded forces, resources, infrastructure, population, transportation systems, and internal and external relationships of the adversary.**

Joint Pub 5.00-1
(Section II-8)

Joint Pub 3-07.3 Joint Tactics, Techniques, and Procedures for Peace Operations (12 Feb 1999)

Tactics such as PSYOPs and Information Operations requires an understanding of the cognitive and cultural makeup of the target, rather than just location and defensive capabilities. In order to get a message across, the sender must know how the receiver is going to interpret the message and respond.

SOF can play a significant role in PKO because of their **unique capabilities, training,** and **experience.** SOF often have detailed regional knowledge of cultures and languages, as well as experience working with indigenous forces… SOF capabilities of PSYOP and CA are particularly important in PO for their understanding of the complexity of operating in cross-cultural environments.

Joint Pub 3-07.3

"If you don't understand the cultures you are involved in; who makes decisions in these societies; how their infrastructure is designed; the uniqueness in their values and in their taboos — you aren't going to be successful."

George Wilson
Commentary in Air Force Times

FM 27-100 Legal Support to Operations (1 March 2000)

MOOTW missions are complex also because of their impact on civilians. Commanders must be prepared to collect human intelligence concerning political, cultural, and economic factors affecting the operation, to conduct public affairs, civil affairs, and psychological operations, to provide humanitarian assistance, to develop ROE that protect the force without causing civilian casualties, to process civilian detainees, to

process requests for temporary refuge or asylum, and to perform other tasks as the mission requires.

FM 3-07 Stability Operations and Support Operations (February 2003)

This manual provides the most up-to-date and wide-reaching view of culture and its importance in operations. In particular, it deals with cultural differences, intelligence gathering, liaison, and negotiation. Of note, culture is included in the IPB process as an artifact: "*The information gathering should focus on areas that influence people, such as cultures, politics, religion, economics, and related factors and any variances in affected groups of people."* At other times, culture also has cognitive connotations: *"Culture shapes how people reason, what they accept as fact, and what principles they apply to decision making."* In any case, this manual provides one of the best views of culture and its implications.

> **Clash of Cultures** (p 1-10)
> 1-30. Some in the non-Western world reject Western political and cultural values. In some instances, regimes that use Western political forms of government are under attack by ethnic, religious, and nationalist groups seeking to establish or reestablish their identity. As tribal, nationalist, or religious movements compete with Western models of government, instability can increase. This instability threatens not only Western interests within the state, but often threatens to spill across borders.
>
> **CROSS-CULTURAL INTERACTION (p1-18)**
> 1-69 Interacting with other cultures can create a significant challenge during stability operations and support operations. Often, adjustments in attitudes or methods must be made to accommodate different cultures. Ethnocentrism and cultural arrogance can damage relationships with other forces, NGOs, or indigenous populations. The welfare and perceptions of indigenous populations are often central to the mission during stability operations and support operations.
>
> 1-70 Army forces must establish good working relations with indigenous populations. Mutual trust and rapport increase the chances for mission success. Army personnel should understand the culture and history of the area. Historical understanding helps soldiers comprehend the society, interact with the people in that society, and adapt to cultural differences to facilitate rather than impede mission accomplishment. Historical and cultural understanding help to determine the range of actions acceptable in solving the problem at hand. With this in mind, soldiers must receive cultural and historical orientations to the people and the conflict. Civil affairs units produce area studies that can provide this information. Interpreters, translators, and linguists are also invaluable.
>
> **PRIORITY INTELLIGENCE REQUIREMENTS (2-4)**
> 2-14. Priority intelligence requirements (PIR) in stability operations and support operations may differ from those in offensive and defensive operations. In combat operations, PIR focuses on the enemy's military capability and intentions. However, intelligence collection in stability operations and support operations may adjust to the people and their cultures, politics, crime, religion, economics, and related factors, and any variances within affected groups of people.

2-15. Generally, in offensive and defensive operations, PIR are answered and targets are attacked and destroyed. In stability operations and support operations, collection and production to answer PIR may be ongoing tasks. For example, PIR related to treaty verification or force protection may continue as long as the mission requires.

Intelligence Preparation of the Battlefield

4-83 Intelligence preparation of the battlefield (IPB) is a continuous process that includes gathering information on areas in which a unit might be required to operate (see FM 2-01.3). It begins before deployment notification and may be based on open-source intelligence. When notification comes, having current information will reduce uncertainties regarding the adversaries, the environment—including the medical threat and terrain in a given area—and facilitate mission planning. Successful intelligence support during PO relies on continuous information collection and intelligence production.

4-84. Ground reconnaissance and meetings with key interagency, international organization, and NGO players are essential to IPB. The information gathering should focus on areas that influence people, such as cultures, politics, religion, economics, and related factors and any variances in affected groups of people.

Intelligence, Planning, CSS, Training, and Manpower Support

5-36. Planning support can be one of the most effective means of supporting the national CD effort. Army personnel support CD planning of both LEAs and host nations. Understanding the supported agency or host nation, its culture, and its people is critical. Planning support provided to LEAs must consider the organization's mission, current goals, structure or chain of command, measures of success, and even relationships with other government agencies or countries. Planning support provided to host nations is similar to that provided to LEAs. However, the host nation's culture, historical perspectives, political climate, and economic conditions are considered.

LIAISON

A-87 The professional abilities of the LNO determine a successful liaison. Additional factors that contribute to successful liaisons are—\

- Knowledge of the doctrine, capabilities, procedures, and culture of their organizations.
- Transportation.
- Language ability.
- Regional orientation.
- Communications.
- Single point of contact in the headquarters.
- In support of humanitarian assistance missions, functional skills and experience aligning with the need for medical and logistics expertise.

BE ATTUNED TO CULTURAL DIFFERENCES (E-1)

E-6. Actions can have different connotations to members of other cultures. Culture shapes how people reason, what they accept as fact, and what principles they apply to decision making. Nonverbal behavior such as the

symbolic rituals or protocols of the arrangement for a meeting also is important.

E-7. Negotiations can be conducted at several levels: negotiations among Unites States (US) agencies and departments; between multinational partners; between the military force and the United Nations (UN) agencies; and between the military and local leaders. In the join, combined, and inter-agency environment, negotiations can be complex. Nonetheless, all negotiations require tact, diplomacy, honest, patience, fairness, effective communications, cross-cultural sensitivity, and careful planning.

NEGOTIATION

CONSIDER CULTURAL IMPLICATIONS (E-2)

There are organizational cultures within the various agencies and departments of the US government as well as the international organizations that shape the context of negotiations. Equally important are national cultural differences. The negotiating team should include experienced interpreters. Their understanding of the cultural context of terms used is invaluable. Negotiators need more than literal translators. Negotiation is only one means of resolving conflict. Negotiators should consider indigenous conflict resolution techniques in selecting their approach. Adapting their techniques with indigenous ones may improve the prospects for a settlement. Some implications to consider include—

•Differences. Differences exist in styles of reasoning, the manner in which an individual who carries authority negotiates, and behavior in such dimensions as protocol and time. For example, American culture accepts that one may offer concessions early in a negotiation to reach an agreement. That approach may not have the same connotation in other cultures. Moreover, the concept of compromise, which has a positive connotation for Americans, may have a negative one in other cultures.

•Each side's approach. Americans tend to be direct problem solvers with a give-and-take approach; however, some cultures are indirect, most concerned with the long-term relationships and historical context. Issues of symbolism, status, and face may be important considerations. For example, answers may not be direct and the negotiator will have to look for indirect formulations and nonverbal gestures to understand what the other party is communicating. In turn, he will need to select his words and gestures with care to avoid communicating unintended meanings.

Alternate locations. Other cultures may prefer alternate locations for negotiations. In 1993 in Kismayo, Somalia, several clans met to seek political reconciliation in a traditional setting under a tree instead of following the American custom of a meeting at a table.

Marine Corp Center for Emerging Threats and Opportunities

The Marine Corp CETO provides some background material on other-culture perceptions of US activity in the Middle East, which are of interest here.

- Cultural Intelligence Seminar on Afghan Perceptions: Quick Look Report, December 2001.
- Islamic Perceptions of the U.S. Information Campaign: Quick Look Report, November 2001.

Summary

"Know your enemy and know yourself and in a hundred battles you will never be in peril." -- Sun Tzu

It has always been understood that "getting into the head of the enemy" is important in military planning and execution. However, this process has typically been biased toward the cultural background of the planner, rather than with knowledge of the culture of the enemy.

Given the above uses of culture from a military perspective, the intelligence requirements about a target area's human element -- principally, the non-military aspects of a built-up area -- include the population and demographic, dates, important culturally relevant buildings, economies, etc. Generally speaking, cultural artifacts such as art and literature are not included in this definition. However, in cases such as the Iraq War, the US military was charged with protecting museums when looting began.

We have shown that aspects of the target area's culture and cultural differences are making their way into military thought and practice. In a sense, this survey gives a flavor of the increasing importance of culture in military doctrine – earlier documents give it only a mention, whereas the latest SASO FM (Feb 2003) mentions culture in many contexts. The current primary users of cultural information at the operational level are the Special Operations Forces. In the planning cells, cultural factors are starting to be taken into account in performing IPB. Some effort is underway in the Marines training courses to instill a sense of cultural differences and how to manage in culturally different environments. However, despite the inclusion of culture and cultural intelligence in some military doctrine, there is little in the way of operational knowledge (tactics, techniques, and procedures) about how to use the knowledge once a target has been analyzed through a cultural lens. There is description, but little prescription.

References

Florin, J. (1996). A Cognitive Explanation for the Influence of Culture on Strategic Choice in International Business. Eastern Academy of Management Meeting, Washington, DC.

Franke, R. H., G. Hofstede and M. H. Bond (1991). "Cultural Roots of Economic Performance: A Research Note." Strategic Management Journal **12**: 165-173.

FM 3.06-11 Combined Arms Operations in Urban Terrain (2000)

FM 3-07 Stability Operations and Support Operations (February 2003)

FM 27-100 Legal Support to Operations (1 March 2000)

FM 34-36 Special Operations Forces Intelligence and Electronic Warfare Operations (30 Sept 1991)

FM 34-130 Intelligence Preparation of the Battlefield (8 July 1994)

FM 100-5, Operations (14 June 1993)

FM 100-23 Peace Operations (30 December 1994)

Joint Pub 3-07.3 Joint Tactics, Techniques, and Procedures for Peace Operations (12 Feb 1999)

Joint Pub 5.00-1 Joint Doctrine for Campaign Planning (25 Jan 2002)

Appendix C

An Analysis of Culture in Iraqi Theater of Operations

29 Oct 2003

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Introduction

This document presents an analysis of the Iraqi theater of operations from a cultural perspective. The example is grounded in the Iraqi war context to provide a clear illustration of how cultural dimensions and core cultural axioms can have power in predicting actions and reactions in two areas: among actors who are making the decisions and among actors who are impacted by those decisions.

Because culture is rooted in history and geography, the explanation begins with some background context about Iraq's history and geography. Since core cultural axioms emerge over time when people in a specific context or environment interact and develop shared understanding about the appropriate way to think and behave given their particular circumstances, knowing something about history and geography provides a broad framework for understanding culture and its impact.

Following the brief synopsis of Iraq's history, the document includes an explanation of some of Iraq's cultural dimensions and core axioms and how they can be used for prediction. The explanation is meant to be illustrative only and not comprehensive of all the cultural dimensions or core axioms that may predict and explain the general patterns of thought and behavior in the Iraq theatre of operations.

The final section of the document explains how the charts illustrate the four levels of operation in a sequential example of a decision.

Background Context

Understanding the context of the military theatre of operations requires understanding some fundamentals about Iraq's history and geography.

- Iraq's history is old. It is known as the cradle of civilization dating back to 2500 BC.
- The Ottoman Empire ruled for centuries, until 1914 when WWI broke out and the Empire aligned with Germany and lost. Great Britain, in negotiations, won the war and at the end of the war had more than one million men in the Arab Middle East. Great Britain drew the new map of Iraq not based on naturally occurring and long-standing cultural groupings, but on what would be best for their interests in Iraqi oil.
- The British wanted to create a system that would protect Western companies' oil interests in the Middle East.
- Iraq is essentially an artificial state that in reality is composed of three long-separate provinces that were separated by natural, physical boundaries and historically distinct cultures tied to their three dominant religious identities: Mosul in the North (Kurds), Baghdad in the Center

(Sunnis), and Basra in the South (Shiites). The Shiites believe that Muslims should be led by a direct blood descendant of Mohammad, whereas the Sunnis do not.

- There are also many tribal chiefs, Jews, Christians and Azeris who contribute to a very diverse and fractious population, all seeking to rise to the top and take control of the country.
- The Ba'ath Party is unique in the Middle East. It began in Syria, founded by two teachers educated in France, as a force to combat British and French domination in Iraq and to foster Arab unity and freedom. The Party came to power in Iraq in 1968 and retained power until its demise in April 2003.
- The Party adopted a mild form of socialism. Under Saddam Hussein, the Party embarked on a program to eradicate illiteracy, build hospitals, schools and universities and played an important role in liberating women and establishing a secular government.
- At the same time, Saddam ruled ruthlessly and practiced strict authoritarian control to keep the country together and cement and protect his power.
- Iraq has, throughout its long history, been a battleground among tribal, ethnic, religious and national forces and is a hotbed of social tensions. In the Muslim world, Iraq has been the center point of conflict between the Sunnis in Turkey and the Shiites in Iran.

In sum, Iraq is a relatively new nation that did not naturally emerge with a single cultural identity. Rather, the nation is politically and diplomatically derived, and it has been held together by a strong authoritarian and secular government. There are at least three major cultural factions in distinct geographic areas, each vying for power. Given the deep cultural roots in Iraq, it will take decades for cultural divisions to be reconciled. In particular, the fundamental split within Islam between Sunnis and Shiites has existed since the death of Mohammad in 632 AD and continues strongly to this day.

Predicting Behavior from Cultural Beliefs and Values

The following examples of cultural dimensions and axioms illustrate how culture can be used to predict or anticipate how a particular group of people might arrive at a decision or react to one.

Iraq

Power Distance

Iraq is a relatively high power distance country where authority is accepted and people wait for those in authority to act on their behalf. Grass roots' organizing in Iraq is not the norm. Therefore, it could be predicted that in the aftermath of the war, the Iraqis would not be quick to self-organize following the toppling of Saddam Hussein. Iraqis look to strong religious leaders to provide authority and direction. They will try to find one who can lead them, and will rally around this leader, looking to the strength of the leader to pull them through tough times and into a position of group dominance. One could also predict that the murder or death of a religious leader will provoke strong negative reaction among a specific population and that there would be a backlash.

In the case of communication with the Iraqi people, one could predict that direct appeals to the Iraqi people will be of limited effectiveness. Communication

campaigns will be more effective if they are directed with targeted messages at the multiple leaders who will be battling among themselves for power. The marginal effectiveness of U.S. propaganda appealing directly to the people with flyers and radio broadcasts would be predictable. There would be mistrust of outsiders, and the people would wait to see what their leaders think and would look to them for direction.

Counterfactual Thinking
In Iraq, the pattern of thinking is based in the analysis of past events through the eye of experience. Given that Iraq's history has been fraught with invasion and control by outsiders, one could predict with relative certainty that outsiders would not be trusted.

Family-Tribe Centered
Trust is based in family and tribal/village ties. Outsiders are distrusted, and their motivations suspect. Given the "in-group" nature of Iraq's culture and Iraq's porous borders and history of invasion, it would be predictable that small cells of terrorists or extremists might go undetected or be ignored because the Iraqi people are focused on their own in-groups that keep to themselves.

Fatalism and Collectivism
Iraq has a religious history that has led to a pattern of belief rooted in fatalism. There is a general acceptance of circumstances, a belief that people have little control over what happens to them, and that they must accept the fate handed to them by God. Fatalism leads to a tendency to accept circumstances and wait for them to change, rather than try to control them. Iraq is also a collectivist, or group oriented culture. Fatalism, combined with collectivism, could be predicted to lead to a willingness to sacrifice individual life for the good of the in-group. In stark contrast, U.S. culture, with its belief in individualism and self-determination, would lead people to believe they can control their fate. This belief can be summarized best in the words of William Jennings Bryant: "Destiny is not a matter of chance; it is a matter of choice. It is not a thing to be wished for; it is a thing to be achieved." It is highly likely that the U.S. forces on the ground would have a difficult time understanding why Iraqis might passively accept their circumstances and not take action into their own hands.

Competition
There is inherent competition among different subgroups in Iraq that is rooted in religious and historical roots, and in natural geographic boundaries. Competition for resources and power will be predicted to continue and intensify when there is a power void.

United States

Individualism
Individualism is the most important core value in U.S. culture. The general pattern of individualism means that the country as a whole, as well as its citizens are likely to act from enlightened self-interest. They will not cooperate in group-level activities unless they can see how it benefits them. Therefore, it would be predicted that the U.S. would act unilaterally without the need for U.N. approval.

Pragmatism
The U.S. approach to problem-solving is generally pragmatic – trial and error; do what works. One could predict that the U.S. would be swift to change tactics in ground operations when circumstances warranted. The command and the troops would not be beholden to the plan or to tradition.

Activity Orientation
The U.S. is a country of "doers" and not "thinkers" in general. Therefore, it could be predicted that in a time of uncertainty, the U.S. would approach a problem by taking action, even if it might not be the best action. The U.S. population also would be likely to be intolerant of inaction on the part of its government and military.

Freedom
At the start of the U.S. history, freedom was the core value above individualism and is still extremely important. One could predict that the U.S. would go to war to fight for a people's freedom. This is justification in and of itself for going to war. The U.S. is not an empire at its core and does not seek to rule others (unlike the British or French or Ottoman empires). Given Iraq's history of Ottoman rule, one could predict that the U.S. motives would be misunderstood by the Iraqi people. They would be unlikely to believe that the U.S. would fight for their freedom and then leave.

Universalistic
The tendency in the U.S. is to believe that certain fundamental values are universally shared, such as the value for equality and human rights. Therefore, it would be predictable that the U.S. troops would enter Iraq believing that the Iraqi people want to have equality under the law, when in fact, they may prefer an unequal and more hierarchical system of governance.

U.S. Military Culture

The U.S. Military culture is a subgroup that does not match the general U.S. cultural pattern in that it is more hierarchical and authoritarian. Authority is more important than influence. It could be predicted that troops on the ground would obey those in civilian authority.

U.S. Government Culture
The U.S. government is founded in democratic values and considers the voice of the people in decision-making. It could be predicted that civilian leaders might be in conflict with military leaders about a course of action because civilian leaders would be worried about acting in accordance with the people's wishes rather than the wishes of a small military leadership group.

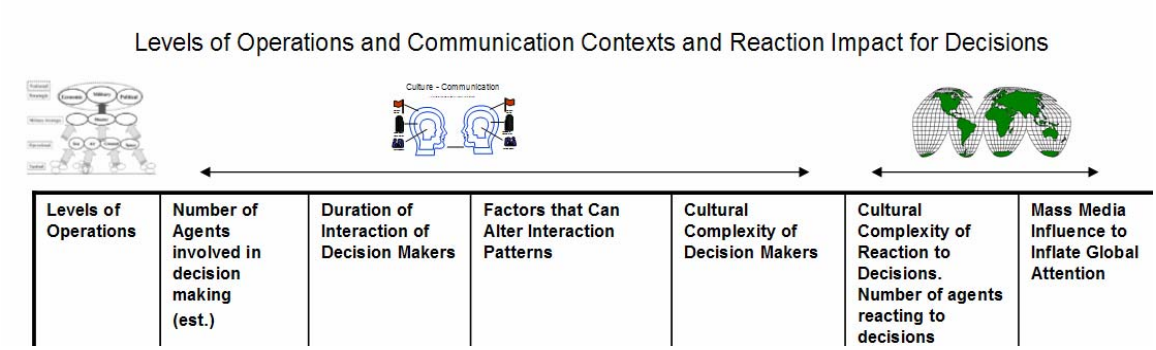
Europe

France:
Theory, ideas and Dialectical reasoning
One of the core axioms for France is "Ideas" or a theoretical and logical orientation to decision-making and problem-solving. The French decision-making process is based in Cartesian logic and the gathering of facts coupled with the analysis of these facts in systematic fashion. One could predict that the U.S. military decision-makers would become impatient with the French decision-makers' desire to continually gather data and conduct prolonged analysis prior to coming to a decision.

Germany:
Order, Thoroughness, High Uncertainty Avoidance
The German pattern of decision-making is rooted in the desire for order and for thoroughness with a well-thought out and detailed implementation plan. The Germans would not be likely to tolerate uncertainty about how to implement a decision. It could be predicted that if the U.S. were to take a quick decision without a well-documented implementation plan, Germany would be likely to reject the decision.

Britain:
Respect for Process
In British culture, tradition and respect for established process, especially the legal process, is a core cultural axiom. One could predict that the British would stand by a legal agreement that was made many years previously, even in the face of evidence that might indicate the agreement was no longer working or appropriate for present circumstances.

Case Example: Iraqi War at the National Strategic Level of Operations



To create the example of culture's influence on the Iraqi war theater of operations at multiple levels, the context was divided into two pieces: the context of the decision itself, and the reaction of various audiences to the decision. The context of the decision is comprised of four areas delineated in the top row of chart, as illustrated above. The first column of the chart indicates the level of operation under consideration in the example, and the next four columns indicate the number of actors involved in the decision making, how long these decision-makers will interact, the factors that can alter their interaction patterns, and the degree of cultural complexity the decision-makers will face in the decision process. Then, given a decision at any level of operation, the last two columns delineate the cultural complexity of the reaction to the decision and how many people (actors) the decision may impact, as well as the likely influence of the intervention of mass media in the reaction.

Each chart illustrates the hypothetical decision process and its effect at each of the levels of operation from National Strategic to Military Tactical. Each of the columns is completed with a brief example or description and the influence of culture is further described in the box at the bottom of each chart.

National Strategic Level

National Strategic Level of Operations: Example

Levels of Operations: National Strategic	Number of Agents	Duration of Interaction of Decision Makers	Factors that Can Alter Interaction Patterns	Cultural Complexity of Decision Makers	Cultural Complexity of Reaction to Decisions. Number of agents reacting to decisions	Mass Media Influence to Inflate Global Attention
*2002 National Security Strategy. *By law, U.S. Pres. Outlines national security strategy every four years.	High level, U.S. policy-makers, particularly security, state and defense.	Long-term, at minimum 4 years	New U.S. President, and regular four-year review. Intensification of U.S. public diplomacy against Iraq.	Moderate, U.S. national culture dominates the formation of policy.	High, global rejection of U.S. position, especially France and Germany, who question evidence, dispute urgency. Support from UK. U.S. threat from Saddam seen as pretext for American hostility and as serving U.S. oil interests. Considered blow to UN, NATO. In Iraq, U.S. aggression seen by Iraqi government as economically driven, by many Muslim as war on Islam, by others as liberation.	U.S. Press reflects connection between Saddam and terrorism. Little criticism of war, general acquiescence. World Press is mixed. Strong Arab reactions of fear and denouncement.

Influence of U.S. Culture: Individualism: Self-reliance, prompted and justified unilateral action. Pragmatism: Focus narrowly on single task – combating terrorism. Little consideration for systemic causes and consequences. Action focus. Freedom: Justification for the war. Preservation of American freedom, tapping into basic U.S. values, allowed policy to gain widespread support in the U.S. Since the U.S. is on the extreme end of the individualism-collectivism continuum, it exhibits much more independence than many other countries and places less emphasis on collaboration or on the importance of the group for its identity, hence more unilateralism. Also, U.S. is more universalistic in its principles, believing that others think in the same way, that its values are shared universally, because they are human values. Hence, the U.S. believes others will interpret its behavior as intended, underestimating the likely alternative interpretations that may be negative.

Influence of European Cultures: The French culture has a strong value for theory, ideas and dialectical reasoning leading them to a long-decision process focused on gathering all the data and weighing all the facts before taking action. Hence, they saw the U.S. as too quick to go to war. The German culture has a strong value for order, and thoroughness and low tolerance for uncertainty and risk, rejecting the U.S. position as not well thought out and risky. The British have respect for process and legal agreements, and saw the war as necessary to uphold loyalties and agreements and reinforce their historical role since WWI.

Influence of Iraqi/Arab Culture: Arabs are counterfactual thinkers and viewed the U.S. strategy as an attack on the Arab world and Islam.

The example begins with the 2002 National Security Strategy, a recurring event that is required by U.S. law to be completed every four years. Since the current security strategy was decided in 2002, just after 9/11, it is a particularly relevant example to illustrate culture's influence on decision making and reaction in the diplomatic and political arena as well as in the military theater of operations. Decisions at the national strategic level represent a fundamental base rooted in a dominant national culture with a few high level policy makers who have interacted over a long period of time to develop the decision. Factors that influence the decision are those that impact the decision-makers themselves, such as a new election and diplomatic events on the world scene. The cultural complexity of strategic decisions is usually moderate since the decision is internal to a country and dominated by the national culture. The reaction to the decision, however, is complex with widespread consequences in other countries. The cultural explanation at the bottom of the chart articulates the influence of the various cultural dimensions and axioms at play in the decision and in the reactions to that decision.

Military Strategic Level

Military Strategic Level of Operations: Example


Levels of Operations: Military Strategic	Number of Agents	Duration of Interaction of Decision Makers	Factors that Can Alter Interaction Patterns	Cultural Complexity of Decision Makers	Cultural Complexity of Reaction to Decisions. Number of agents reacting to decisions	Mass Media Influence to Inflate Global Attention
Joint Chiefs Plan Iraq War Strategy	High level, U.S. joint chiefs, with security, state and defense personnel	Long-term high level hypothetical strategic planning on joint war fighting, called Joint Vision 2010, a conceptual blueprint published in 1996.	Improved reconnaissance and war technology. Military pension for continuous improvement.	Moderate, U.S. national and military culture dominates the formation of strategy.	Primarily bi-cultural, among subcultures in the U.S. Cultural tension between military and civilian leaders. Consequently, military post operation compromised by civilian dominance with too few troops and not enough planning for post-war occupation.	U.S. Press intensifies tension by reporting conflict. Fosters strategic leaks of information to give impression that military force greater than actually engaged. Arab Press pick up on and exploits leaks.

Influence of U.S. Military Culture: U.S. military culture is focused on goal achievement and a linear, sequential four-step process for military action – deployment, build-up, decisive operations, and post-conflict operations. Reflects U.S. task orientation. Effectiveness is more important than efficiency. Authority (higher power distance than norm for U.S. population as a whole) is more important than influence.

Influence of U.S. Civilian Government Culture: Civilian culture is more egalitarian and democratic (low power distance) than the military and focused more on efficiency than effectiveness. The voice of the people is important to decision-making, and since civilians must be accountable to the people, longer-term consequences are more important than just winning the war (elections).

Influence of Iraqi/Arab Culture: Arabs accept authority of Arab Press and anti-U.S. sentiment grows.

The example at the Military Strategic Level carries the example from the National Strategic Level in sequence to illustrate the cultural differences within the U.S. between the U.S. military culture and the U.S. civilian political culture as the implications of the national strategic decision are worked out in military strategy.

Military Operational Level

Military Operational Level of Operations: Example

Levels of Operations: Military Operational	Number of Agents	Duration of Interaction of Decision Makers	Factors that Can Alter Interaction Patterns	Cultural Complexity of Decision Makers	Cultural Complexity of Reaction to Decisions. Number of agents reacting to decisions	Mass Media Influence to Inflate Global Attention
U.S. leads Iraqi Invasion without U.N. or World Support	Hundreds, across all armed forces with integrative command and control	Short-term, months, with rehearsal and war-gaming and subsequent deployment in accordance military strategy	Negative diplomatic relations for staging on the ground in theater of operations.	Low, bi-cultural primary between the U.S. and British, with some Australian involvement. Differences negotiated smoothly for command and control.	High, surrounding Arab countries ambivalent about lending ground and air space for build-up and deployment. Turkey refuses to allow staging, as did Saudi Arabia. Limited support delayed and complicated troop movement,	World press provides large scale coverage. Highlights political tensions and lessens support on the ground for troops internationally. U.S. Press increases popularity of war at home. U.S. conducts media campaign in Iraq among people.

Influence of U.S. Military Culture: U.S. military culture is accustomed to managing uncertainty and unpredictability and to high risk situations, but the nature of diplomatic relations intensifies uncertainty and places operations in more compromised position.

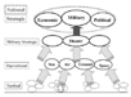
Influence of U.S. Civilian Government Culture: U.S. action orientation and achievement orientation focuses attention on the task of removing Saddam and the Iraqi regime. Short-term orientation does not do justice to longer-term post-conflict occupation concerns.

Influence of Iraqi/Arab Culture: Iraqi culture is high context and high power distance, and authority is accepted primarily from in-group leaders based on relationships. Media campaign to appeal to Iraqis directly of limited value because the people do not respond to messages from outsiders, and are not inclined to self-organize. Iraqi leadership conducts counter-campaign based in authority relations not in facts.

Again, this chart carries the example to the next lower level at which military operational decision are made, such as the placement of U.S. soldiers in the Iraqi Theatre. This decision is constrained by the two previous levels, and culture's impact on military logistics becomes clear in the reactions to the decision. It is at this operational level that the media plays a dominant role.

Military Tactical Level of Operations

Military Tactical Level of Operations: Example




Levels of Operations: Military Tactical	Number of Agents	Duration of Interaction of Decision Makers	Factors that Can Alter Interaction Patterns	Cultural Complexity of Decision Makers	Cultural Complexity of Reaction to Decisions. Number of agents reacting to decisions	Mass Media Influence to Inflate Global Attention
Military troops engage in combat throughout the theater of operations	Thousands of troops integrated in centralized command and control engaging with opposition forces and population	Short-term, conflict-based, followed by long-term conflict ridden post occupation	Continued post-war conflict, guerilla sniper tactics, suicide bombings and Iraqi looting, instability caused by local Iraqi inter-group conflict	Low, often bi-polar, primarily U.S. Christian troops in interaction with individuals in belonging to specific local cultures: Kurds, Sunnis, Shiites primarily	Thousands of people reacting to localized incidents, generally based in reactions of U.S. troops to localized Iraqi cultural circumstances and of Iraqis to occupation by U.S. or British troops.	Conflicting media reports from U.S. embedded reporters and Al Jazeera representing the Arab voice. U.S. localized media campaigns are weak.

Influence of U.S. Military Culture: U.S. troops are primarily Christian and have U.S. values. They believe in the rights of individuals, have a tendency to trust civilians, are more optimistic and have a high value for individual life. They are low context communicators with little ability to read the nuanced cues in their Iraqi environment. Consequently, Iraqi military often abandoned uniforms and continues surprise attacks using civilian clothes as camouflage. Iraqi extremists use civilians as suicide bombers.

Influence of Iraqi/Arab Culture: In loss of hierarchical power and authority structure, Iraqi society reverts to long-term, historically-based loyalty to cultural groups. Group competitiveness resurges as traditional cultural ties outweigh national cultural identity which was held together by strict authoritarian control under Saddam. Arabs revert to local tribal, religious and family/community groups who are trusted, to fill the power vacuum. Communication and influence must be channeled through leadership of each group to reach Iraqi population. Strong distrust of out-group Americans and out-group Iraqis. Low tolerance for risk and uncertainty leads to anti-U.S. sentiment when infrastructure is in chaos.

The final chart illustrates the military tactical level in a primarily bi-cultural context (Iraqi culture – U.S. culture). However, there are thousands of potential interactions in both the decision-making process as well as in the reaction to the decisions. These interactions can be fueled by intensive media coverage. Hence, there is the potential for many misunderstandings, all of which can be broadcast to large audiences.

Summary

A consideration of culture's influence on planning for operations needs to include the impact of history and geography on the cognitive level in decision-making and reaction, as well as the relevant cultural dimensions and core axioms that have grown out of people's interactions in a specific context over time. In the cognitive structure, culture influences both the nature of the decision-making process and the reactions among the populations affected by the decision. Given the four levels of operation, national strategic, military strategic, military operational and military tactical, there are significant differences in the number of actors involved in the decision process, in the duration of their interactions, in the factors that can alter the decision process, and in the cultural complexity of the decision-making and the decision reactions. Given these differences, different aspects of culture may come into play at the different levels of operations, and planning (and tools that support planning) must account for these differences.

Appendix D

Taxonomy of Cultural Dimensions for Military Operations and Tools

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Revised 30 October 2003

Introduction

We have found many various uses of the term culture through the literature, including military and social sciences uses that are often incompatible. The motivation for this document is to augment the common use of the term "cultural" with research from the social sciences that has attempted to identify universal dimensions along which cultures vary. Specifically, we want to look to these sources for information that would help inform a computational model of human behavior that takes culture into account. First, a literature survey of common uses of the term culture and of military documents (such as Army Field Manuals) has produced a definition of culture that covers the most common aspects of culture. (See another document entitled "A Survey of the Use of the Term Culture in Military Operations".) From a military perspective, information about these things we have called "civil intelligence," as a way to indicate the non-military information elements of information that are important in urban operations, specifically Stability and Support Operations (SASO). We define civil intelligence to encompass a few categories: physical setting, political considerations, socio-cultural, economic, media, and external influences (Table 1).

Civil Intelligence Categories *Intelligence derived from all sources regarding the social, political and economic aspects of governments and civil populations, their demographics, structures, capabilities, organizations, people, and events.*					
1. Physical Setting	2. Political	3. Social-Cultural	4. Economic	5. Media	6. External
• Topography and Underlying Terrain • Boundaries • Physical compositions and Neighborhoods • Civil Infrastructure • Buildings	• State Institutions and structures • Government administration (actors) • Political Organizations (actors) • Criminal organizations	• Population Demographics • Population Culture	• Resources and Production • Commerce and Trade • Finance • Transportation • State Roles • Foreign Roles • Power structure	• Media sources and channels • Media controllers (actors)	• International Actors, organizations • Non-government Organizations (NGO's)

Table 1: Civil Intelligence Categories

A further breakdown of the Socio-Cultural element of civil intelligence, under the name Population Information, includes languages, history, religions, social groups, customs, cultural styles, etc. Table 2 gives a broad listing of this breakdown.

Table 2: Population Information

Population Information

Culture

- Languages
- History, development of city, region & nation-state
- Religions (beliefs & institutions)
- Social groups
  - Ethnic, race, tribe/clan, religious
  - Segmentation, distribution, history, power
  - Leaders, elites, followers
  - Relationships with state, groups
- Customs, attitudes, social taboos
- Social roles of population segments (women, elders)
- Cultural 'styles'
  - Negotiating
  - Persistent, historically-based perceptions, outlooks, temperaments
  - Distinctive organizational behavior (political, economic, social)
- Culturally significant locations
- Dates, events

The information in Table 2 could be further categorized into the how quickly the information changes. For example, those types of information that is very slow to change, and so quite fixed over the course of a military operation, would include the language of the area, the historical aspects, the major social groups, the customs and attitudes, and cultural styles. Other types of information have the potential to change during the military operation, including who the major players (especially leaders) are in the area of operations, what their relationships are to each other. This is where the definition of "civil intelligence" found in the language of the military breaks with the definition that comes from the social sciences. Specifically, culture to the social sciences is a set of knowledge (beliefs, customs, language, etc.) that is passed from one generation to the next. Here, individual leaders in power at the time are not really important to the enduring nature of the culture. There are exceptions, of course. A leader such as Muhammad, although no longer alive, still has an impact on culture. The socially transmitting information about a culture is something easily derived from anthropology or history books; some of the more specific information about the current leaders and their relationships is something that must be found out by other means, including local intelligence gathering.

Cultural Variation

The social sciences define some aspects of culture not captured in the above, or with a different perspective than given in Table 2. A first distinction is that culture variation can be divided into three broad categories: behaviors, values, and cognition. Behavioral differences include language, social rules, and customs. Values are principles for evaluating alternatives or consequences in decision-making (Keeney 1994). Cognition describes different processes used for problem solving, perception, attribution, and decision-making. Research over the last few decades has produced a further breakdown of the values dimension of culture, with an effort to identify a set of universal cultural traits that can define variation within a culture. Likewise,

psychological research has indicated variability between cultures in a few cognitive categories. Table 3 summarizes some of the dimensions identified in the sciences.

Table 3: Dimensions of Cultural Variance

Dimensions of Culture		
Behaviors *The outward, observable artifacts (including structures and institutions) of a culture*	**Languages, Customs, Dress, Religion**	The normal definitions for these…
	Personal Space (Hall 1959)	The region around an individual, within which it is considered taboo (to varying degrees) for another individual to enter that space.
	Language Styles – High vs Low Context (Hall 1959)	The extent to which a culture's communication includes large amounts of non-verbal cues (gesture, situational context, etc.) in verbal interaction
Values **The base judgments of good and bad common to a culture**	**Power Distance (Hofstede 1980)**	The acceptable difference of power between a superior and a subordinate
	Uncertainty Avoidance (Hofstede 1980) (and Risk Avoidance)	The value an individual attaches to a perceived risk; how much an individual experiences uncertainty as stressful, and how much they avoid it
	Time Orientation (Kluckhohn et al. 1961)	Whether the individual is focused on the past, present, or future in making decisions. Called 'Confucian Dynamism" by Hofstede.
	Activity Orientation (Kluckhohn et al. 1961)	Whether the individual is inclined more toward efficient, pragmatic solutions of goals, or more focused on the interpersonal relationships developed during problem-solving
	Independence / Interdependence (Markus et al. 1991)	Whether an individual views him- or herself as an independent entity or related to some larger whole. Similar to Hoftede's "collective
	Masculine vs Feminine (Hofstede 1980)	The extent to which a culture favors "nurturing (feminine) behavior"
Cognition *The preference-based strategies used in decision-making, perception, and knowledge representation*	**Dialectical Reasoning (Peng et al. 1999)**	Whether options are delineated to show their differences, or whether those options are merged to maintain possibly contradictory perspectives
	Hypothetical Reasoning (Markus et al. 1991)	Whether the individual uses hypothetical (imagined) circumstances to show implications of actions, or grounding analysis in context and experience
	Counterfactual Reasoning (Markus et al. 1991)	Whether the individual uses counterfactual (untrue, explicitly opposite what is known to be trust) circumstances to show implications of actions
	Perception (Ji et al. 2000)	The tendency for people perceive objects in a scene as relating to other objects in that scene
	Attribution (Choi et al. 1999)	How people of different cultures attribute causality across cultures

An example will help illustrate these differences in practice. Hofstede determined that the primary culture of the United States measures low on the Power Distance scale, meaning people expect low distance in power differentials between those in power and those not in power, and high on the Independence-Interdependence scale, meaning US citizens tend to be more independent in their thinking, not taking into account the benefit of the group in much of decision-making. Alternately, it appears Iraqis score high on the Power Distance, and low on Independence-Interdependence, meaning they're more tolerant of a tyrant, and their decision-making is focused on the group – often the family unit. The US exhibits low-context language use, meaning an utterance carries much of the content; Iraqis seems to exhibit high-context language use, meaning non-verbal cues such as gesture play a high role in communication. Note that Hofstede did not include Iraq among the nations he evaluated. However, we might extrapolate from surrounding countries (Iran, Turkey) to get a sense of Iraq's general tendencies. (For more examples of how these countries differ along the cultural dimensions, see the document entitled "An Analysis of Culture in Iraqi Theater of Operations".)

Putting Culture to Work

Given the breadth of these dimensions, and how fundamental they are to the human decision-making processes (at all levels, from national policy down to individual choices), it is difficult to see how to separate culture from other human activities, such as those categories set out in Table 1: politics and government, economies, etc. It might be said that culture, at the individual level, informs the decision-making and perception of all those categories. Culture is certainly not the only factor involved in any process or organization, but it helps define everything from the organization of the government and military, to the information on billboards, to the colors used in advertisements.

These dimensions as stated have interesting implications from a few different perspectives. International diplomacy, interactions within bodies such as the UN, military operations planning and execution, and peacekeeping and support operations all deal with different cultures at some point. Either in one-on-one dealings with foreign leaders, or boots-on-the ground operations in a foreign country, the cultures of the participants play a role in the interactions and the outcomes of those meetings. With different cultural backgrounds, there is a large chance for miscommunication and misunderstanding, so going into these situations with as much awareness of those differences, and how to manage them, can only help these meetings.

One might ask how this information could be packaged in an understandable format for use in these contexts. The research community is not always interested in end-user acceptance, and that's clear from the terminology used to describe these dimensions. Much of the focus in those documents (Field Manuals, and the like) is on the behavioral aspects of culture: dress, food, religion, important dates and customs, and especially social taboos. Conceivably, these same manuals could be extended to include information on the other dimensions.

To spell out how these dimensions might play a role at different levels in the military decision-making process, Table 4 presents the cultural dimensions as crossed against strategic, operational, and tactical contexts of use.

	Dimensions of Culture		Implications / How is feature Manifested?		
			Strategic *National/Theater mission objectives, using diplomatic, economic, and military means to accomplish goals (policy)*	**Operational** *The organization of mid-level objectives into plans to accomplish strategic goals*	**Tactical** **The implementation of plans in terms of observable activity "on the ground"**
National Cultural Features	Behaviors *The outward, observable artifacts (including structures and institutions) of a culture*	Language Dress Customs Religions Low vs High Context Personal Space	Religion Type of government Mass communication (policy explanation)	Language barriers in coalition planning Social rules governing house-to-house searches	Language Barriers Religious Norms Gender/Age Roles and Rules Language Barriers Social Norms (shaking hands, personal space) In-group/Out-group relationships/constraints Family Structure Interpersonal communication
	Values **The base judgments of good and bad common to a culture**	Time Orientation Power Distance Individualism vs Collectivism Masculine vs Feminine Risk Avoidance Activity Orientation Independence vs Interdependence	Trust formation Risk tolerance in uncertainty among coalition partners Risk tolerance in uncertainty of slow reconstruction effort Consensus-building in coalition	Speed of decision-making Locus of D-M in Organization (Command Authority) Risk tolerance in uncertainty Trust formation Perception of risk in situations Distribution of Authority in targets understanding PsyOp communication	Speed of decision-making Consensus-building Risk tolerance in uncertainty Response to threats Trust formation Perception of risk in situations Negotiation Dynamic Reciprocation of acts Face saving

	Cognition *The preference-based strategies used in decision-making, perception, and knowledge representation*	Hypothetical Reasoning Counterfactual Reasoning Dialectical Reasoning	Negotiation, argumentative styles; use of evidence and hypothetical reasoning to justify policy decisions	Perception of consequences Negotiation styles Argumentation styles Causal attribution	Perception of consequences Negotiation styles Argumentation styles Causal attribution

Table 4: Dimensions of Culture and their Implications

For the purposes of this program, we are interested in building tools to support the military planning process in SASO operations, which – we've argued – must take into account non-military (i.e., civil) information, such as given in Table 1. For automated tools for decision support and planning, it seems obvious that this information needs to be taken into account in the evaluation of courses of action, but (as with any such tool) these tools differ in the level of detail they require. For example, in order to understand how a target population might interpret a broadcast radio-based PsyOp campaign, it is not necessary to know how they typically dress – so the simulation designers would leave out that detail. As an example on the other end of the spectrum, other automated tools, such as individual soldier training stations, where the soldier can interact with synthetic entities representing members of other cultures, in critical situations such as negations, house-to-house searches, and crowd control. In such an environment, all the dimensions cited above might come into play, including behavioral, wherein the entities in the simulation must outwardly appear to be representative of the target country or region. As shown by Table 4 above, it is important to know a hypothetical tool's range of use to determine the level of fidelity it must eventually provide to its users.

To develop such tools, we might look toward Human Behavior Models as a means to representing cultural variation. Human Behavior Models attempt to capture the cognitive processes in a wide range of applications, from societies to individuals, in a wide range of problem-solving contexts. While these models vary widely in their purposes and their ability to model individual decision-making with high fidelity, the premise is largely the same. Often, such models are embodied in autonomous software agents that populate a synthetic environment, and that can respond to their environment and to other agents in that environment. Such a model provides a worthwhile basis for constructing simulation tools that include human decision-making as a critical element. With this agent perspective in mind, the dimensions listed for values and cognition are attractive from a Human Behavior Modeling standpoint. Agent activity is typically founded in perception, problem solving, decision-making, valuation and judgments. A long-term goal of this effort, then, could be to frame the dimensions in such a way that they could be used to define a framework for defining or moderating the decision-making process of a "normative" agent. The extent to which these dimensions can be cast as predictive (rather than strictly descriptive or explanatory) will help determine their suitability for this sort of agent-based modeling.

Another wrinkle is the level of culture considered. Generally, we think of culture on a national scale, and the above research focuses on national variation, though it is not the only type of culture. Uses of culture include terms like *corporate culture* or *military culture* implies the use of culture for smaller segments of a society, including functional organizations or regional variations. Furthermore, an individual is typically part of multiple cultural groups simultaneously, defined by region, occupation, interests, etc. For example, a person could be part of a country (the US), a region (the North), an industry (information technology) and a company (IBM). Each of these organizational groups represents a different culture, and recent research suggests ways in which these multiple cultures affect behavior in the same individual ((Franke et al. 1991); (Florin 1996)). A model of culture will inevitably have to take into account these different cultures and their interplay.

Summary

This document draws a distinction between elements in culture by their lifespan: those that might change over the course of a military operation, and those aspects

that are very slow to change over time. This distinction can be described in military terms: those things that need to be gathered and updated frequently (via sensors, intelligence processes), and those things that change slowly enough as to be called constant during the course of a military operation. Here, we consider only those slowly-changing aspects of culture, and examine them from the perspective of recent research in psychology and sociology. Research in these areas has identified several dimensions along which cultures vary, categorized broadly into behaviors, values, and cognition. We have placed these dimensions in relation to military operations, and speculated about their value in constructing tools that include cultural factors. Much work remains in the definition of computational models of culture, but these dimensions seem to be a useful place to start the process.

References

Choi, I., R. Nisbett and A. Norenzayan (1999). "Causal Attribution Across Cultures: Variation and Universality." Psychological Bulletin **125**: 47-63.

Florin, J. (1996). A Cognitive Explanation for the Influence of Culture on Strategic Choice in International Business. Eastern Academy of Management Meeting, Washington, DC.

Franke, R. H., G. Hofstede and M. H. Bond (1991). "Cultural Roots of Economic Performance: A Research Note." Strategic Management Journal **12**: 165-173.

Hall, E. (1959). The Silent Language. Greenwich, Conn., Fawcett Publications Inc.

Hofstede, G. (1980). Culture's Consequences International Differences in Work-Related Values. Newbury Park, SAGE Publications, Inc.

Ji, L., K. Peng and R. Nisbett (2000). "Culture, control, and perception of relationships in the environment." Journal of Personality and Social Psychology **78**: 943-955.

Keeney, R. L. (1994). "Creativity in Decision Making with Value-Focused Thinking." Sloan Management Review(Summer): 33-41.

Kluckhohn, F. and F. L. Strodtbeck (1961). Variations in value Orientations. Evanston, Greenwood Press.

Markus, H. and S. Kitayama (1991). "Culture and the self: Implications for cognition, emotion, and motivation." Psychological Review **98**(2): 224-253.

Peng, K. and R. Nisbett (1999). "Culture, dialectics, and reasoning about contradiction." American Psychologist **54**(741-754).

Appendix E

Consideration of Urban Sunrise Tool Use Case

Urban Sunset
Jack Zaientz
V2. Oct 3 2003

Preparation of Environment
The definition steps described here may make the system seem like a greater data consumer than it needs to be. The intent of this system is not to represent all aspects of the modeled area at the same level of detail. Geographic areas, built features, population groups and individuals only require sufficient information to support the current analysis goals. Individual entities, for example, may be represented by a name and group affiliation only, or be sufficient detail to enable simulation, at the discretion of the analyst and based on available data. In addition, it is assumed that this initial preparation phase would take place prior to field use.

1. Define Geo-spatial Area
    a. Load base map
    b. Load reference layers
        i. Load Terrain Features
        ii. Load Built Features
        iii. Load Population layer
        iv. Load Schematic layers (Communications, Power, …)
        v. Load Cultural Significance Annotations layer (what built and natural features are considered significant by population)
        vi. Load Cultural Regions layer
    c. Define Named Areas of Interest (NAOI)
2. Define Known Population Groups and Entities
    a. Define enemy, belligerent groups and group characteristics if any.
    b. Define main ethnic and social groups and group characteristics
        i. Define group calendar
        ii. Define Resources controlled
        iii. Define current group activity
    c. Define local kinship groups, civilian governments and other organizational structures, including influence and communications, and decision making patterns
    d. Define inter-group relationships, including communication, trust, and influence
    e. Define specific known entities (local leaders, key individuals)
3. Define BlueFor
    a. Define BlueFor groups, including joint & coalition forces
    b. Define BlueFor ROE & Policies
    c. Define official and unofficial contacts with other groups
4. Define select Groups/Entities as simulation Actors
    a. Identify entities to be simulated
    b. Define simulation characteristics of key entities
5. Define necessary environmental conditions
    a. Define natural conditions such as climate and water levels
    b. Define artificial conditions such as infrastructure integrity

Periodic Updates

These updates will be based on current intelligence reports and will be entered into the system on a periodic or as-needed basis by the analyst or analyst support staff.

1. Identify BlueFor, RedFor and GreenFor actions & reactions of interest
2. Update Geo-spatial data
    a. Update natural and built feature conditions (have buildings been destroyed? Water treatment plants come on line?)
    b. Update schematic layers (have broadcast stations gone off-air? Have water delivery systems been disrupted? Have security installations blocked local communications?)
    c. Update NAOI's
    d. Annotate model changes with data source information
3. Update Population Groups and Entities
    a. Update geo-spatial locations and dispositions of opfor groups & civilian populations
    b. Update known information about specific groups or entities
        i. Locate Group/Entity
        ii. Update Characteristic
        iii. Annotate model changes with data source information
    c. Annotate model changes with data source information
4. Update Simulation Actors
    a. Locate Group/Entity
    b. Update Characteristic
    c. Annotate model changes with data source information
5. Update Environment
    a. Locate Environmental feature
    b. Update feature
    c. Annotate model changes with data source information

Simulation Management

Simulation management is primarily an automated process. Development of this process is an open problem area and the following use cases under-defined.

1. Mark data update as complete
2. Run new simulation sets
    a. Run simulation sets based on defined Blue policies
    b. Run simulation sets based on defined Red or Green strategies
3. Identify main and outlier result sets
4. Prepare output data for presentation

Situation Analysis

Situation analysis is an open-ended process consisting of main and supporting tasks. Primary system usage will follow standard data analysis process; (In exploratory analysis Step 2 precedes 1)

1. *Formulate questions*
2. *Identify data sets of interest*
3. *Organize data in frame that supports the answering of questions*
4. *Analyze data*
5. *Record observations & formulate new questions*

1. Identify analysis questions
    a. Record questions and problem space in log

2. Explore regional map
   This basic exploration pattern is required for each display set available. Each display set will have different data presented or highlighted and allow different comparisons.

   Regional maps will support multiple layers enabling the analyst to locate cultural and social features in a geo-spatial context. Individual layers will include built features, population demographics, current military situation, schematic networks including power, water, and communications.

   a. Select Blue Policy Set
   b. Identify NAOI's status based on simulation outcome
   c. Identify groups or individuals of interest status based on simulation outcome
   d. Compare identified NAOI's, groups or entities with previous map / highlight changes from current map
   e. Compare identified NAOI's, groups or entities with other Blue policy set
   f. View NAOI's in regional context
   g. View specific NAOI details on secondary display
   h. View correlating information on alternate displays.
   i. Annotate map with new NAOI's, and symbolic and textual comments

3. Explore Schematics
   Schematic displays will enable the analyst to view schematic networks focusing on attributes of the network other than location.

4. Explore Groups & Entities
   Group and Entity displays will individual and aggregate current status and simulation history. This includes annotated relationship (link) graphs, and cultural impact diagrams. This will also include a range of cognitive level presentations of entity decision-making.

5. Explore Simulation Narratives
   Analysts will view simulation evolution over time using timelines, text narratives and animated computer graphics (i.e. movie/computer game type displays)

Appendix F

A Computational Model of Trust in SASO

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Abstract
We describe an agent-based simulation testbed for exploring trust relationships between agents in a cooperative/competitive environment. The testbed consists of an implementation of a basic agent interaction model, and a computational model of trust added to the interaction model. We demonstrate this testbed in a simple three-agent model, and explore the implications of trust with respect to Security and Support Operations (SASO).

Background

The experiments are meant to explore the space of the urban operations environment from the perspective of trust: how do the actions of the different agents affect the trust relationships, and what are the conditions under which trust evolves?

Several lessons have come out of the recent war in Iraq. First, the military planners underestimated the totality of the regime's grip over the people and the fear of reprisals that was so ingrained. There was also an inherent distrust by the Iraqi people of the intentions of the US, fostered by a continual stream of misinformation by the regime, as well as historical cases such as the US abandonment of the Sunni rebellion in Southern Iraq near the end of the first Gulf War. Furthermore, the Iraqis view the US, with all its money and resources, as capable of fixing their broken infrastructure, and the fact that such things have not yet been completely corrected makes the population distrust the motives of the US.

This information has implications in the anticipated plan of Urban Sunset. Among other things, it highlights the fact that urban operations is (partly) a matter of winning hearts and minds – in other terms, it is a matter of winning trust. In order to win the hearts and minds of the population such that the US can accomplish its mission, the US must first establish an environment of trust among the relevant parties. Without some level of trust from the population to the coalition forces, in terms of maintaining security, establishing a legitimate government, etc., the coalition faces an even longer road to nation building in Iraq.

Trust
Trust, as a concept, is multi-faceted, and has many definitions in philosophy, psychology, and sociology, and business. However, a fairly common definition is given by (Huff et al. 1999) Trust is:

> *The confident expectation that, in a situation relevant to the trustor, another party (the trustee) will act in the trustor's best interest, and the willingness to rely on and be vulnerable to the trustee.*

One critical aspect of trust is that the trustor makes the decision to trust the trustee to do something based on the assumed trustworthiness of the trustee.

Table 1 : Factors influencing person-based trust (borrowed from (Adams et al. 2002))

Category of Factors	Factors Influencing Person-Based Trust	Description	Impact on Trust
Qualities of the Trustee	Competence	Possessing the skills, characteristics, and abilities to allow us to meet the demands of a given situation	Competent people are more likely to be trusted because they possess skills and abilities which lessen the risk of negative outcomes [Mayer et al., 1995]
	Benevolence (Positive Motivation)	The extent that a trustee is seen as wanting to do good to a trustor, independent of their self-interests	Highly benevolent people are more likely to be trusted – believing that others are well intentioned reduces risk and uncertainty
	Integrity	Credible communications, a strong sense of justice, and consistency of word and action (Mayer et al., 1995).	Integrity increases trust, as it provides consistency of word and action, and makes people's behaviour more predictable
Qualities of the Trustor	Propensity to Trust	Tendency to trust others, often cited as a product of developmental experiences, and seen as consistent across time and across situations	Propensity to trust can influence both whether people engage in relationships with others, and the attributions that they makes within these relationships
	Trust History	Past history of trust interactions with other people	A positive trust history makes trust in future relationships and situations more likely
Qualities of the Interaction	Communication	Both the exchange of information and the openness with which the information is exchanged	Open communication (e.g. sensitive and/or unsolicited information) provides evidence about another's trustworthiness [Lewicki and Bunker, 1996] and can facilitate trust. Information exchanged provides evidence of goodwill and a desire for deepened relationships [Das and Teng, 1998].
	Shared Values and Goals	Values: "*general standards or principles that are considered intrinsically valuable ends (e.g., honesty, reliability)*) [Jones and George, 1998]. Goals are desired end states.	Shared values provide standards by which to judge whether another person can be trusted [Jones and George, 1998]. Knowing a person's goals provides information about future behaviour. This increases their predictability and enhances trust.
	Similarity	Similarity may include age, sex, marital status, as well as cultural or ethnic background, life experiences, attitudes, technical background, training, etc.	People may be attracted to people who are similar [Mayer et al., 1995] and this may lead to more global positivity about all of their qualities, including trustworthiness. Similarity may provide a basis for assuming that other's behaviour will be similar to one's own [Kramer, Brewer, & Hanna, 1996].

Researchers have identified four stages of person-based trust (Adams et al. 2002):

1) Predictive model based on observed behaviors
2) Attributions of motives and intentions
3) "Leap of Faith" in unknown situations
4) Identification with trustee's desires and intentions

Not mentioned explicitly in the Adams work is the influence of culture, which others have shown to have a significant influence on trust. Recent work has shown how cultural factors influence trust (Doney et al. 1998), and some theoretical models

have been built to illustrate these influences. (Huff et al. 1999) present a model of trust development that integrates many of these influence factors. Their model is of particular interest to us in that it integrates aspects of culture into the model. They explore the integration of at least one of Hofstede's dimensions of culture (the individualist versus collectivist dimensions), and provide possible locations where other such dimensions might be incorporated. One implication is that collectivist societies–those whose decision-making is group-oriented–tend at first to distrust out-group members more than individualist societies do, but have the potential to develop more trusting relationships over time. (Lundgren et al. 2003) demonstrate a theoretical model of how *Power Distance* and *Uncertainty Avoidance* influence trust formation in economic relationships.

There has been some work modeling trust in a computational framework. (Dasgupta 1988) proposed the "Trust Game", an iterated social game of self-interested interacting players, which has received some attention in the game theory world. Related work includes that of Axelrod on iterated Prisoner's Dilemma (Axelrod 1997). (Prietula 2001) and (Prietula et al. 1998) describe agents engaged in a task, and demonstrate the effects of trust and rumor on the ability for the agents to perform their tasks. This work most closely matches the Prietula and Carley work. The differences will be discussed later.

Experiment Testbed

There are two components of the model. First, a model of interaction via resource allocations and communications. Second, a computational model of trust. These two components meet where trust is defined by behavior, and behavior is affected by trust. The dynamics of the model are driven by the link between behavior and trust.

Interaction Model

The basic model is a set of multiple agents connected by interaction paths. Each agent knows which other agents with which it can interact, and may know of other agents in the system with which it does not have direct links. Figure 1 illustrates a basic agent network setup that might represent a SASO environment.

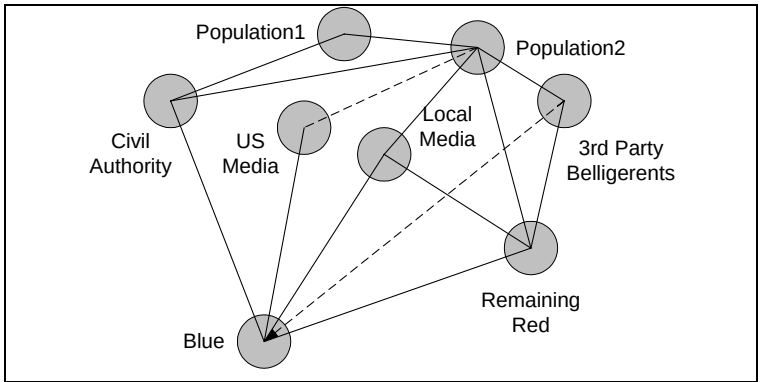


Figure 1: An example basic social network

Agents

Agents are decision makers in the model. Agents' basic currency is its resources, which it can give to or take from other agents. Resources represent things like food, water, and manpower. Each agent's resources are divided into two types: stored and

allocated. The stored resources represent the available pool to draw from, which is drawn from for the allocated amount of resources. Allocated resources are what's used for donating or attacking another, or for defending against an attacker. When a donation is made, the amount is subtracted from the donator's allocation, and added to the donatee's pool. When an attack is instigated, the losses on both sides are drawn from the allocated amounts. Each agent also has defined rates at which resources are moved from the resource pool to the resource allocation. Also, to represent a rate of use, the resource pool is used up at a determined rate. The pool may also be set to be increased at certain intervals, to mimic "donations" from external actors not represented in the system as agents.

Agents may have goals, which indicate idealized situations (with respect to certain variables/statistics/etc. in the agent's knowledge.) Agents also have beliefs about other agents, including what their resources are, and whom they've interacted with in the past. The agents do not currently take into account the anticipated results of their actions. Instead, we use simple policies to determine when actions should be taken, which (may) take into account goals. Table 2 summarizes the attributes for each agent in the system.

Table 2 : Agent Attributes

Agent Attribute	Definition
Inputs	Actions performed by other agents; messages sent to this agent
Resource Pool	The resource pool from which to draw allocation
Allocated Resources	The current available resources for actions and defense
Beliefs	Any knowledge about the world, including information about other agents
Goals	Agent's desired condition of certain variables
Policies	Rules for determining action.
Outputs	Actions (resource moves, communications)
Resource allocation rate	Rate (amount per n turns) at which resources are moved from the pool to the allocation
Resource burn rate	Rate (amount per n turns) at which resource pool is used up
Resource reserve ratio	Amount of allocated resources the agent wishes to reserve (not use) during an attack
Other agent	Another agent in the environment, with attributes such as a name, relationship (friendly/enemy), and its amount of resources
Events	Record of interactions with other agents (donations, attacks)

The agent's basic operation is the decision-making behind whether to manipulate resources. The basic agent execution of each agent is be the standard perceive-decide-act cycle:

1) Perceive the recent system activity
2) Decide what action to do (if any)
3) Perform the action decided upon

Table 3 presents the actions an agent may take during the course of the simulation.

Table 3: Agents and their actions

Agent Category	Actions
Donate resources	Give a determined amount of resources to another agent
Attack	Use a determined about of resources to attack another agent
Communicate own resources	Tell another agent resource pool and allocation amount
Communicate event	Tell another agent about an event that occurred (a donation or an attack)
Communicate other resources (intel)	Communicate to an agent about another agent's resource pool and allocation

Attack Model
We currently use a simple combat model based on the attacker and defender amounts engaged in the conflict:

A = attacker amount
D = defender amount

[1] Attacker losses = A * (1 – A/(A+D))
[2] Defender losses = D * (1 – D/(A+D))

One by-product of combat is that each side knows the amount allocated to the attack. However, since the attacker does not have to use all of its resources, the defender may only learn of a portion of the attacker's allocation. The attacker, on the other hand, learns of all the defender's allocation.

Game Cycle
Because we are using agents based in the Soar cognitive architecture (Laird et al. 1987), the game time is counted in Soar decision cycles, which is a measure of rule firing quiescence for an agent. It is not a fixed timeframe; rather, when all the agents have finished firing rules that match their current state, a decision cycle turns over, and the game clock is incremented.

The entire game operates by each agent deciding at each turn to perform an action, and then performing it. All interactions are done via message passing in a simple infrastructure. When an agent receives a message, it is processed for content, then (if required) it is responded to. This is the essence of the interaction model. There are some simple rules that moderate the system flow in such a way that there are no race conditions, and data is consistent at all time. Each agent in the system follows these rules. Examples include:

- No agent may engage in two battles at the same time. If you've been attacked, you must complete that engagement before trying to attack someone else
- Complete an attack before telling someone else about your resources
- Wait until resources changes (due to burn rates, etc.) have changed before telling someone else about your resources

Statistics and Logging

Agents keep a history of interactions with other agents, including statistics about the interactions. Examples include the agent's current resources (pool and available) number of times an enemy attacks, the average size of the attack, the frequency of attacks, etc.

Additionally, each agent is responsible for logging statistics and events as they occur in the game. These are stored as comma separated variable (".csv") files, for easy reading in spreadsheet programs.

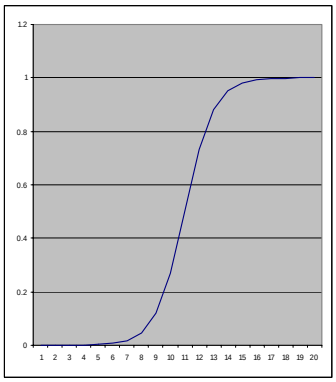
Computing Trust

Atop the interaction model, we overlay a computational model of trust. We present a partial implementation of the Huff and Kelly model of trust (Huff et al. 1999). The Huff and Kelly model distinguishes between specific trust (toward a specific agent) and general trust (toward a category of agents). Each of these types of trust is composed of four basic characteristics, as defined by (McKnight et al. 2001): benevolence, integrity, competence, and predictability. Benevolence (B) is the tendency for the trustee to act in the best interests of the trustor. Integrity (I) is the tendency for the trustee to fulfill its promises. Competence (C) is the ability of the trustee to meet its goals. Predictability (P) is the tendency for the trustee to act in a consistent manner. From this, we define trust as a weighted average linear combination of these characteristics for both specific and generic trust. Weights are provided for each characteristic to denote the importance of that characteristic to the trustor. We can think of the attributes as a vector of features based on the trustor's perception of the trustee. Weights on vectors capture effects of culture (and potentially other factors) on the base vectors – importance of certain attributes over others, etc. Each trustor agent assigns different weight to these categories of trust. Here we use w_c to denote weight for Competence, etc. As such, we compute trust as a weighted linear average:

[3] $$\text{Trust} = (w_c C + w_b B + w_i I + w_p P)/(w_c + w_b + w_i + w_p)$$

We do not implement all aspects of the Huff and Kelly model, partly in the interest in time, but partly because the model is not clearly defined in some areas. For instance, Huff and Kelly do not elaborate much on the emotional component of trust, so we will not currently include emotion as an aspect of this model. We acknowledge that emotion plays a critical role in real trust relationships, but without a good sense of how to integrate emotion, how emotion arises, etc., we will not burden this study with added complexity.

Note that the model they present was nominally meant to describe the interaction between persons. We will use this same model to describe interactions between groups of people, with the idea that a single agent that reflects the "aggregate" behavior of a group. We understand there may be limitations in this mapping, such as we lose the ability to examine some aspects of individual behavior within groups. However, this simplification (we believe) will yield interesting results nonetheless.



There is no available data to indicate how to compute the individual components of trust as given by McKnight and Chervany, and there is no consensus on equations for trust or its components. In the absence of a standard model, we make some hypotheses here. In this model, elements of trust are computed as a sigmoid using different terms. A hypothesis posited here is that many of the trust components follow the sigmoid function, $1/1\text{-}e^{-x}$. This equation yields values on the interval [0.0,1.0], which makes it attractive for normalization. Scaling the x factor stretches or shrinks the width of the curve. Additionally, the rates of change associated with the sigmoid are attractive in that they can capture time effects, such as a slowness to change at the beginning, and the capped effects of repeated successes. Negative x values yield a curve that starts high and ends low.

What follows are the equations for the components of trust [3], many of which are modulated to range across their values within a certain range of time (all else being equal, 0.0 to 1.0 in 100 turns).

Competence (C) – having the ability to fulfill goals
[4] $1/1\text{-}e^{-x}$
where, when goal is met,
x = (time-outside-goal * (actual-goal-level – desired-goal-level)) / 10
or
where, when goal is met,
x = (time-within-goal * (actual-goal-level – desired-goal-level)) / 10
Interval [0.0, 1.0]

Benevolence (B) – tendency for trustee to act in interest of trustor
[5] $(1/1\text{-}e^{-x}) - 0.5$
where x = (time-since-last-attack-against-me – last-attack-amount) / 100
Interval: [-0.5, 0.5]
Here, negative numbers indicate the trustee actually harms the trustor.

Integrity (I) – tendency for trustee to fulfill its promises
[6] $1/1\text{-}e^{-x}$
where, when goal is not met,
x = ((number-friendly-attacks-against-enemy ^2) * 100+ (number-attacks-against-me^2)+ total-time-elapsed + 1000/totaltime+2)/1000

where, when goal is met,
x = ((num-friendly-attacks-against-enemy ^2) * 10+ (num-enemy-attacks-against-me^2)+ total-time-elapsed + 1000/totaltime+2)/1000
Interval [0.0, 1.0]

Predictability (P) – consistency of trustee's actions, enabling forecasting
[7] Probability(trustee-attacks-enemy | recently-told-about-enemy-resources)
Interval [0.0, 1.0]

General versus Specific Expectancies
In addition to the trust threshold, the outcomes are dependent on the starting positions of trust (what Huff & Kelly call "Generic Trust", or trust based on generic

data, independent to specific interactions). We address the combination of General Trust with Specific Trust by including the elements of Generic Trust. Here we define GC to be Generic Competence, and w_{gc} to be the weight for GC, etc.

[7] $$\text{Overall Trust} = \frac{(w_c C + w_b B + w_i I + w_p P + w_{gc} GC + w_{gb} GB + w_{gi} GI + w_{gp} GP)}{(w_c + w_b + w_i + w_p + w_{gc} + w_{gb} + w_{gi} + w_{gp})}$$

If the trustor has a propensity to trust, the likelihood of success is greater; if trustor is more suspicious, the likelihood is lessened. For example, assigning low constant values to the General Trust components, and including them in the sum of Trust, we introduce a dampening effect on overall Trust.

Trust Threshold

(Marsh 1994) suggests there is a trust threshold above which the trustor will impart trust to the trustee. Marsh computes the Trust threshold (what he calls the Cooperation Threshold) using competence:

[8] Cooperation Threshold = (Risk * Importance) / (Competence * Trust)

With low competence, the Trust threshold is very high. As competence increases, the threshold decreases. However, it is not clear from Marsh's work how his definition of competence varies from McKnight and Chervany's definition, and since our Trust is computed with competence as a factor already, it's not clear how to integrate these two models.

Experiment Methodology

We explore a three-agent model: Red, Blue, and Population. In this scenario, Red is attacking Population, and it is Blue's job to intervene to protect Population. This might be analogous to the situation in Kosovo between the Serb nationalist government driving out the ethnic Muslim Kosovars, with the UN forces entering to protect the Kosovars, or as seen in Iraq today where part of Blue's job is the security of the population.

In this model, we introduce the notion of the Population's Security, measured as the frequency and size of attacks by Red against the Population; specifically, the scaled average number of attacks (ScaledAveAtt) per turn. That is:

[9] ScaledAveAtt = ave-attack-size * total-number-attacks / total-cycles

One variable here, then, is the goal of the Population: the acceptable level of ScaledAveAtt over the course of a run.

In this model, Trust is manifested in the exchange of information. When the Population's trust for Blue exceeds a threshold, the Population will tell Blue all it knows about Red's resources. For these experiments, the only trust relationship we examine here is the Population's trust toward Blue. Table 4 gives the agents used in these experiments, and the policies they use.

The method here is to run multiple simulations, incrementally varying the Cooperation Threshold, to see how long goal achievement takes under varying thresholds. We run the gamut from complete trust (threshold = 0.0) where

Population always tells Blue, to zero trust (threshold = 1.0) where Population never tells Blue, with increments of 0.05.

Table 4: Agents and their policies

Agent	Policies
Red	Attack (Population or Blue) with 75% of allocation. If given a choice, prefer to attack Population over Blue
Blue	Attack Red with 75% of allocation when 75% of allocation yields a 3:1 force ratio over Red.
Population	Always tell Blue about Red attacks on Population If trust > threshold, tell Blue about Red resources

Assumptions
It is assumed that Blue has the intention to help Population, and the Population knows this, so in the absence of any other information, integrity is assumed at the start. As the model progresses, however, integrity does change.

Population always tells about Red's resources when Population is attacked, but that information may not be accurate (Red may not attack with all its available forces) and may not be timely (Blue may only be able to act some time after the attack occurred, which means the information is out of date). Also, Red always tells Population about its resource levels.

We hold Predictability as constant (=1.0) for these experiments.

For simplicity, we examine a single situation (Population's security), so there is no need to distinguish between trusts in different situations.

Varying Trust Threshold
Trust is manifested in the Population's willingness to cooperate with Blue by telling Blue about Red's resources when they are known. We use a Cooperation Threshold to determine at what level (trust > threshold) the Population will start telling Blue about Red's resources. The question, then, is what effect does trust have on the time it takes for the goal to be accomplished? For this experiment, we hold constant the Population's goal level of ScaledAttFreq < 0.5 (below 0.5 is within goal level). To determine the effects of changing the Cooperation Threshold, we ran 21 runs of 300 cycles each were performed varying the Trust threshold from 0.0 to 1.0, at intervals of 0.05.

Experiment Results

Table 1 summarized the length of time required to get within the goal for each of the trust thresholds, given for thresholds t=1.0, t=0.6, and t=0.0.

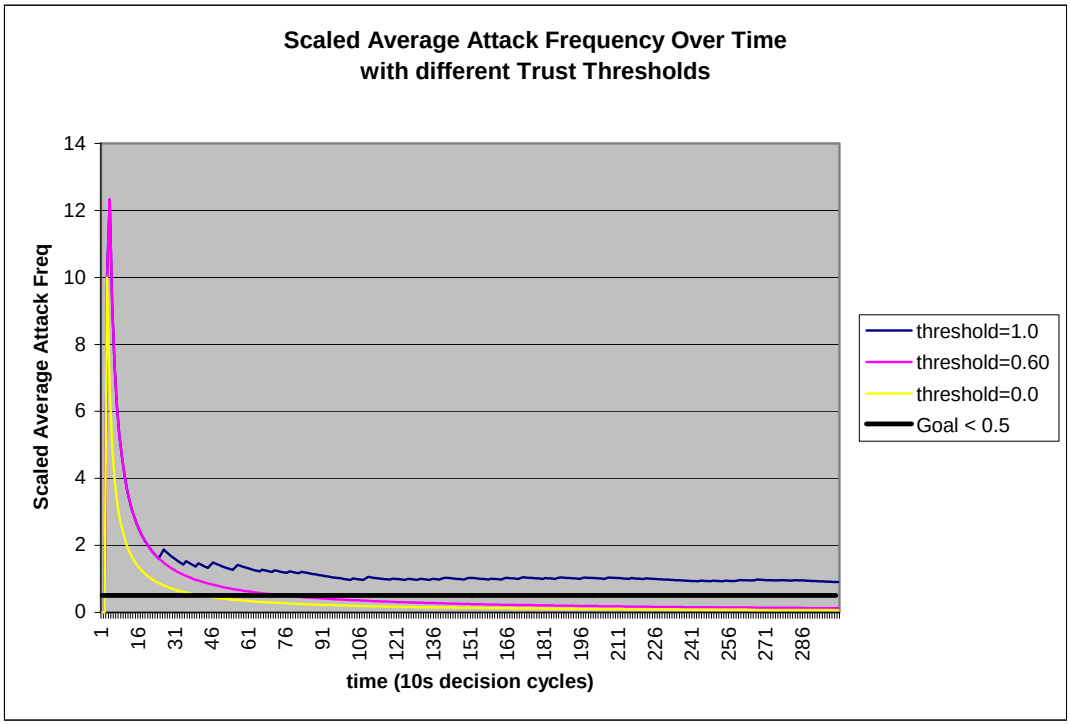


Figure 2: Scaled Average Attack Frequency over time

The initial spike at the beginning of each data set in Figure 2 is a result of initialization starting some values at 0. Soon after running, the Red agent attacks the Population agent a few times, quickly raising the scaled attack average. Over time, these all settle out to their stable paths.

Partly in the name of clarity, we present only three runs through this space, with thresholds at 0.0 (complete trust), 0.6, and 1.0 (no trust). The base results here reflect what is somewhat intuitive: the more Population trusts Blue, the quicker the goal is achieved. At threshold=1.0, the goal is not achieved within the given run. At threshold=0.6, the goal is achieved within 75 time units. At threshold 0.0, the goal is accomplished within 41 time units.

The three runs we show in the above graph was not arbitrary. In fact, the three bins are pretty strong attractors: after around 200 cycles, these are the only three averages that exist, within a standard deviation of 0.0. With Cooperation Thresholds above 0.64, the goal is not accomplished in the 300 time units run (though might after much longer). With the Cooperation Threshold between 0.63 and 0.51, goal achievement takes 73 time units. With a low threshold between 0.0 and 0.50, goal achievement takes only 41 time units. This is summarized in Table 5.

Table 5: Time to Goal Achievement for Different Trust Thresholds

Threshold = 1.0 - .64 (no trust)	Threshold = .63 - .51	Threshold = .50 - 0.0 (complete trust)
Never	75 cycles	41 cycles

The model exhibits quite a bit of sensitivity to initial conditions such as force ratio between Blue and Red, and initial trust values (generic trust). For example, if generic trust is reduced, the overall trust results are discounted by the same amount, and the goal takes longer to achieve, proportional to the discounted amount. So, in fact, this translates to the quicker Population consistently trusts Blue, the quicker the goal is achieved.

The graph in Figure 3 below shows the evolution of trust over the duration of the experiments, for the three previously mentioned thresholds (t=1.0; t=0.6, and t=0.0). The inset shows the evolution of the components of trust for the t=0.60 case. Here, predictability is held constant. Benevolence is computed based on the frequency of attacks on the Population (Blue does not attack Population). So, in this scenario, Integrity and Ability play the largest role. Integrity is the measure of the trustee's tendency to fulfill its promises. In this model, Blue has an implicit promise to protect the Population. Also, trust is improved when the trustee shows an ability to achieve the goal – in the graph, we see a visible bump appear at around time=75, corresponding to when the goal threshold was crossed for this case. The oscillation that is visible in the t=1.0 case is a reflection of the inability for Blue to gain a foothold enough on Red to reduce the Scaled Average Attack Frequency. When the information coming to Blue is based solely on Red's attacks on Population, which (as previously noted) are infrequent, and may be inaccurate and out of date, Blue cannot compensate enough to meet the goal. A tipping point at t=0.64 is clearly visible, where trust above that point converges above the Cooperation Threshold, and trust below converges below.

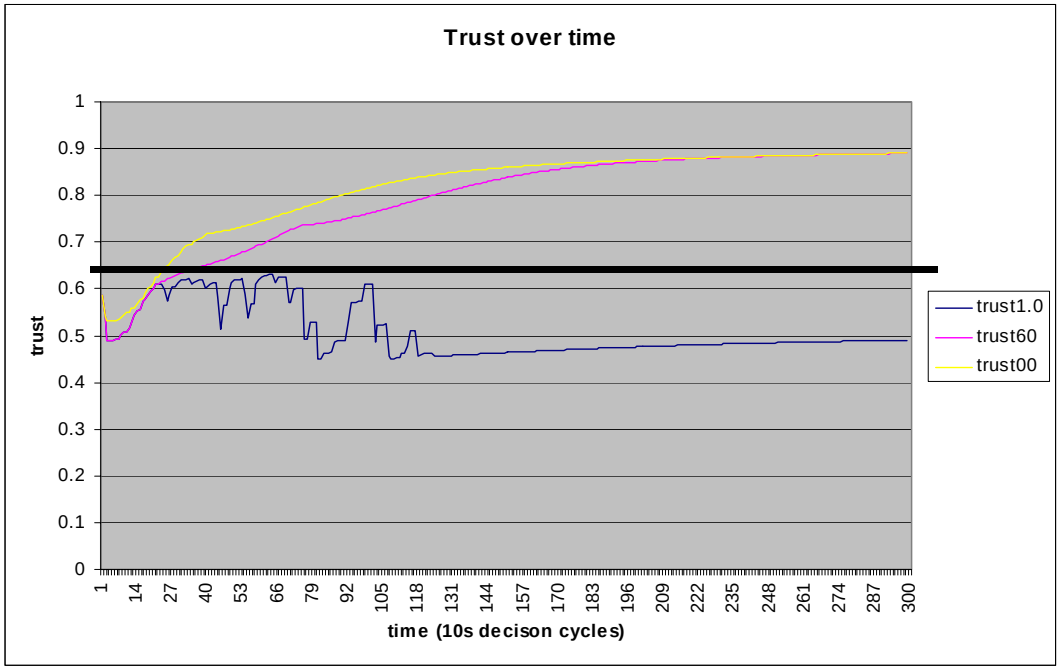


Figure 3: Trust Over Time

The tipping point is a confluence of a few factors. As mentioned previously, because the initial conditions result in trust near 0.5, and using the fixed Cooperation Threshold, very quickly we see these three trust trajectories arise, corresponding to the three intervals [t=1.0-0.64, t=0.63 – 0.51, and t=0.50-0.0], where the latter two intervals result in eventual goal achievement, and the high interval does not.

Discussion

Several researchers have built computational models of trust. As mentioned earlier, (Marsh 1994) developed a computational framework of trust, and demonstrates experiments that incorporate the framework. More similar is the work by (Prietula et al. 1998), which includes the notion of goals and goal satisfaction as a metric for the value of trust in social situations. There are a few differences. First, whereas Prietula's model uses only a variant of Predictability based on direct interactions and rumor from others, we use a more sophisticated equation for trust based on the (McKnight et al. 2001) model. Similar to Prietula, we include goals in the characterization of trust; however, we include goal satisfaction directly in the computation of some trust components. For example, an agent is more likely to trust another if the agent's goals continue to be met – with some presupposition that part of that satisfaction can be attributed to the other agent.

Cooperation with the Blue forces, predicated on trust, was required for Blue to accomplish the goal of the Population. Similarly, in Iraq, as the population has begun to trust the coalition forces more, they've started to be more forthcoming with information about opposition forces. As trust grows, likelihood is greater for cooperation. Of course, there are many more factors at play than simply trust, but trust is a necessary factor in modeling the total dynamic.

There are certainly some problems with the model as described. Aside from the basic equation of Specific/Generic Trust [equation 3], it does not seem that the model

given here is easily generalized. The variables used to compute each of the components of trust are very specific to this agent-based model. Even within the same model, a single component may be defined differently for different agents and the relationships between them (ie, enemy versus ally).

Generic Trust and other experimental configurations

Generic Trust is meant to capture "preconceived notions" about categories of people, without knowing anything about specific individuals. When all one knows about an individual is a perceived category of belonging, Generic Trust has a higher influence than Specific Trust in the total Trust computation. In these experiments, we explored this by changing the value of Generic Trust, and found that the total Trust value was essentially varied by the Generic Trust amount. Basically, if we treat a "distrusting" person as discounting trust by 0.25, this essentially lowers the tipping point by that same amount. So, in the above experiment, the tipping point would be t=0.39. Above this threshold, the goal is never met. A more sophisticated model would vary the importance of the Generic Trust aspect with respect to overall Trust (i.e., lower the w_g's in equation [7]) over time, allowing Specific Trust toward an actor to increase in importance in a given situation.

We have run other simulations that include a computation of collateral damage in the attack model, where bystanders (those agents who are neither attackers nor defenders) can suffer some damage proportional to the total size of the conflict (attacker resources + defender resources + bystander resources). The general output looks similar. However, since we treat collateral damage similar to a direct attack, if the Blue agent is the attacker, Population will reduce Blue's Benevolence, thereby lowering the total trust given to Blue. As such, trust would take longer to have an effect on the goal.

For this initial experiment, we limited the agent population to three, with fixed relationships between the agents. However, different configurations of the same agent triad, or the additions of new agents, would likely change the trust dynamics in the system.

Framing Trust in SASO Operations

This model's results can be colloquially related to SASO operations. In the post-war efforts in Iraq today, we see similar effects. When the Iraqi people trust the US forces enough to tell about the locations of regime-supporters, weapons caches, and the like, US forces are more likely to eliminate those threats, thereby increasing the overall security of the area. On the other hand, the Population's lack of notification to Blue regarding Red's resources can be seen as a kind of tacit complicity with Red: without that information, Blue is hampered in its effort to accomplish the goal. Indeed, actual events show that Population sometimes directly supported Red by telling them about Blue. In order to capture these subtleties in this model, one option is to encode Population as two distinct groups, those supporting Red and those who are Neutral or leaning toward Blue.

What this model does not explicitly account for is the fear of reprisals from Red if Red finds out that Population is giving information to Blue. In a situation such as in Iraq soon after the fall of Baghdad, the Population was not sure of the regime's demise, and feared retributions for cooperating with the coalition forces. This could perhaps be accounted for in competence – that Blue can protect Population from reprisals – but making this explicit might be beneficial.

Conclusions

The trust model presented here is a basic implementation that has allowed us to explore the role of trust within interacting agents in a SASO setting. The experimentation described here supports the notion that trust enables one's goals to be achieved more quickly.

Clearly, more work needs to be done for the model to exhibit the richness we see every day in the news reports about the progress being made in Iraq. However, while the model is still quite underdeveloped, the results shown here are in line with other research done on trust (see, for example, (Prietula et al. 1998)). The simplified resource exchange model is a useful metaphor for agent interactions, even if it has limits. Additionally, the model developed has potential for exploring many other elements of trust including cultural factors as shown in (Huff et al. 1999) and others. The adoption of this model as the basis for Trust computation allows a broad exploration of the effects of trust, and the factors that influence trust itself.

The area that needs the most work here is the mathematical formalization of the sub-components of trust. There is little data to indicate how they should be computed, and little data at this level against which to compare the hypothetical equations posited here. Beyond this, the model must be extended to support more than dyadic trust relationships, and must account for the potentially different computations of trust between different agents. The model must also be extended to include more goal-oriented decision-making to determine best actions, including judgments of utility and likely effects of actions.

At this point, the model does not appear to be general across different models or simulation environments. The basic model that trust is composed of specific and generic trust, and even the linear combination of factors, is certainly quite generic. However, the individual characteristics of trust are each computed in terms of very specific simulation artifacts. For example, we use statistics such as time since last attack, scale of attack, and goal achievement to compute benevolence, integrity and competence. If these were not available in another environment, the current equations would not work. It is perhaps reasonable that these same statistics might be drawn from a richer simulation. However, it may be that there are other statistics available in that richness that could be used in these computations.

Regardless of these drawbacks or simplifications in the current model, the research that went into its development, and even some of the results, indicate that trust relationships must be represented in a simulation that means to take into account the civil aspects of an area of operations.

References

Adams, B. D. and R. D. G. Webb (2002). Trust in Small Military Teams. 7th ICCRTS, Québec.

Axelrod, R. (1997). The Complexity of Cooperation: Agent-based Models of Competition and Collaboration. Princeton, NJ, Princeton University Press.

Dasgupta, P. (1988). Trust as a Commodity. Trust: Making and Breaking Cooperative Relations. D. Gambetta. Oxford, Basil Blackwell**:** 49-71.

Doney, P. M., J. P. Cannon and M. R. Mullen (1998). "Understanding the Influence of National Culture on the Development of Trust." Academy of Management Review **23**(3): 601-620.

Huff, L. and L. Kelley (1999). Trust Formation in Collectivist and Individualist Societies. 8th Cross-Cultural Consumer and Business Studies Conference, Cancun, MX.

Laird, J. E., A. Newell and P. S. Rosenbloom (1987). "Soar: An architecture for general intelligence." Artificial Intelligence **33**(3): 1-64.

Lundgren, H. and R. Walczuch (2003). "Moderated Trust - The Impact of Power Distance and Uncertainty Avoidance on the Consumer Trust Formation Process in E-Retailing." unpublished manuscript.

Marsh, S. (1994). Formalizing Trust as a Computational Concept. Department of Computing Science adn Mathematics. Sterling, University of Sterling**:** 184.

McKnight, D. and N. Chervany (2001). Trust and Distrust Definitions: One Bite at a Time. Trust in Cyber-societies. R. Falcone, M. Singh and Y.-H. Tan. Berlin, Springer-Verlag.

Prietula, M. (2001). Advice, Trust, and Gossip Among Artificial Agents. Dynamics of Organizations: Computational Modeling and Organizational Theories. A. Lomi and E. Larson. Cambridge, MA, MIT Press.

Prietula, M. and K. Carley (1998). A Computational Model of Trust and Rumor. AAAI Fall Symposium Series - Emotional and Intelligent: The Tangled Knot of Cognition, Orlando, FL.

Appendix G

Cognitive Layer Design Document

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Background

This document describes a vision of the cognitive layer of a 3-tier simulation (cognitive, symbolic, and physical) for Urban SUNRISE, a tool to assist in the military operations planning process. The simulation as a whole will help planners explore the impacts of military action on the civil (non-military) aspects of an area of interest. Where required, this document will describe requirements or expectations of a physical and symbolic layer, but concentrates on the information and processes at the cognitive layer.

The cognitive layer represents the mental processes and activities that occur in the minds of the human participants. In Urban SUNRISE, we will model this layer by means of agents that represent either individuals or groups of individuals engaging in deliberative process of decision-making. In the case of models groups, we will take the group as an aggregate with a single agent representing the majority of the populous. If finer distinctions are required, creating two agents that occupy approximate the same neighborhood would be justified.

Humans, and therefore the agents in the simulation, are influenced by many factors in their decision-making. The situational context of the decision (including historical context), the other players surrounding the actor, the actor's goals, beliefs, perceptions, and decision-making styles all play a role in the decision-making process and its outcome. The description of an agent system that models these factors is given below.

Agent Design

Agent Network
The organization of the agent network is data-driven. The connections between agents must be dynamic and not fixed to a particular decision-making process. If there is a hierarchical organization required (in terms of group decision-making, for instance), the agents in that group must have the appropriate knowledge to perform the decision-making using the protocols dictated by the organizational structure.

Actions
Agents interact with other entities and objects in the world by means of *actions.* Actions can take the form of *world actions* (i.e., those actions that directly impact the world model) and *communicative actions* (i.e., actions that are communications with other agents).

Table 1 : Agent-controlled entities in the system: attributes, observables, actions.

Entity Type	Attributes	Primary Layer	Sensed By	Senses	Transformations	Transmission
ALL OBJECTS	Identifier					
Civilian Leaders, Groups, Populations (AGENT CONTROL)						
Leadership Group	Group Association Health Needs Population Econ Status Educ Level Use Permission	Physical	Visual	Visual Broadcast Sound Telephone Cell Phone Internet	Store Health Store Money Permit/Restrict Change Op Status	Msg. Private Msg. Public Msg. Telephone Msg. Cell Phone Msg. Internet Move (self)
Neighborhood Population	Group Association Health Needs Population Econ Status Educ Level Use Permission Unrest Level Safety/Security Personal Freedom	Physical	Visual	Visual Broadcast Sound Telephone Cell Phone Internet	Store Health Store Money Build Create Resource Repair Change Op Status Protest Demonstrate Riot Damage/Sabotage	Msg. Private Msg. Public Msg. Telephone Msg. Cell Phone Msg. Internet Move (self)
Faction or Opposition Cell	Group Association Health Needs Population Econ Status Educ Level Use Permission	Physical	Visual	Visual Broadcast Sound Telephone Cell Phone Internet	Store Health Store Money Build Create Resource Repair Change Op Status Damage/Sabotage Destroy	Msg. Private Msg. Public Msg. Telephone Msg. Cell Phone Msg. Internet Move (self)
Human Military, Security, Humanitarian Forces (possible agent control)						
Blue Mil Forces	Group Association Damage Status Power Needs Alert/Patrol Lvl Force Level	Physical	Visual	Visual Broadcast Sound Telephone Cell Phone Internet	Store Power Build Create Resource Repair Change Op Status Demolish Damage Destroy Restrict Movement	Msg. Private Msg. Public Msg. Telephone Msg. Cell Phone Msg. Internet Move (self)

Red Mil Forces	Group Association Damage Status Power Needs Alert/Patrol Lvl Force Level	Physical	Visual	Visual Broadcast Sound Telephone Cell Phone Internet	Store Power Build Create Resource Repair Change Op Status Demolish Damage Destroy Restrict Movement	Msg. Private Msg. Public Msg. Telephone Msg. Cell Phone Msg. Internet Move (self)
Civilian Security Forces	Group Association Power Needs Alert/Patrol Lvl Force Level	Physical	Visual	Visual Broadcast Sound Telephone Cell Phone Internet	Store Power Change Op Status Restrict Movement	Msg. Private Msg. Public Msg. Telephone Msg. Cell Phone Msg. Internet Move (self)
Civilian Engineering Forces	Group Association Power Needs Population	Physical	Visual	Visual Broadcast Sound Telephone Cell Phone Internet	Store Power Build Repair Demolish Create Resource?	Msg. Private Msg. Public Msg. Telephone Msg. Cell Phone Msg. Internet Move (self)
Humanitarian Convoys	Group Association Damage Status Power Needs Resources	Physical	Visual	Visual Broadcast Sound Telephone Cell Phone Internet	Build Create Resource Repair Change Op Status Restrict Movement	Msg. Private Msg. Public Msg. Telephone Msg. Cell Phone Msg. Internet Move (self)

World Actions in Urban SUNRISE

In terms of the world model, actions are transforming processes on object state information. See Table 2 for actions across different entity types in the simulation.

We expect not to represent very rich blue actors in the simulation. Instead, the user will either act turn by turn or decide the general “policy”/”strategy” of the blue side, and a simple (perhaps somewhat reactive) mechanism will drive the policy forward.

Table 2 : Blue Actions

Blue Player Actions
Patrol
Zone Flood
Raid
Cordon & Search
Arrest & Detain
Demolish
Destroy

Communication Actions in Urban SUNRISE

Communication actions consists of sending a message to another agent for purposes of requesting information, negotiation, informing, etc. There is necessarily an originator of the message (called the *speaker)* and the intended recipient of the message (called the *hearer)*.

Formally, communication is described as a seven-step process:

From the Speaker's side:

1) Intention: Speaker has intent to communicate
2) Generation: Speaker forms utterance U to communicate
3) Synthesis: Speaker communicates utterance U

From the Hearer's side:

4) Perception: Hearer hears utterance U*
5) Analysis: Hearer evaluates possible meanings of U*
6) Disambiguation: Hearer decides on intended meaning of U*
7) Incorporation: Hearer decides to add U*'s content/meaning into belief structure/knowledge

Ideally, U = U*, but errors in communication, noise in the medium, and other intermediate processes may corrupt the original utterance before receipt by the hearer.

Prior to step 1 above is the planning process that creates the intention to communicate, whereby the agent considers among possible actions (some non-communicative) what is the best thing to do. It would be likely that much of the work in steps 1-3 would be done as part of the consideration process, and steps 4-7 might be imagined by the agent based on its understanding of the intended hearer.

We will adopt a framework based partly on Speech Act Theory (Searle 1969), and, specifically, Searle's taxonomy of performatives:

Assertive: commit speaker to the truth of a statement
Directive: get the hearer to do something
Commissive: committing the speaker to some future action
Expressive: express the psychological state of the speaker
Declarations: causes the declaration to be true after having been spoken

Grounding communication in the structures the agents natively think about is critical. In the case of AGILE, we have **goal**, **action** and **situation** objects that can easily be

transported around as referents in an utterance. AGILE's current procedural representation of beliefs make them less likely candidates for conversation in the near future.

Table 3 : Taxonomy of Communication in Urban SUNRISE

Communicative act	Content	Form	Example
Assert	An declaration of "fact": a subset of the world state	:type statement :content (world-state (variable value)+)	(CivilPop1) Neigh1.BluePatrolLevel = .6
	Re-sending of another communicative act (with possible change	:type statement : content (originator when message)	(Cleric1) BlueMil 1 turn ago said "I promise to perform Arrest&Detain on turn 3"
Commit (conditional)	Commitment to (not) actionX in future	:type commitment :content (action when)	(BlueMil) I promise to perform Arrest&Detain on turn 3
	Commitment to (not)(creating) world state = (not) stateY in n turns	:type commitment :content (when) (world-state (variable value)+)	(BlueAgent) On turn 4, I will make Neigh1.BluePatrolLevel < .3
	When WorldState (not) = StateX, then we'll (not) perform ActionY n turns later (presumably this resembles and agreement more than a threat)	:type commitment :content (antecedent world-state (variable value)+) (action who when)	(RedOpposition1) When Neigh1.BluePatrolLevel > .7, I promise to attack Neigh1 1 turn later
Threaten	If you (not) perform ActionX, then we'll (not) perform ActionY	:type threat :content ((antecedent action who when	(BlueMil) If you do not move out of Neighborhood1 in 3 turns, we'll attack Neighborhood1 in 4 turns.

	If WorldState (not) = StateX, we'll (not) perform ActionY (threats entail commitment)	positive/negative) (resultant action who when positive/negative) :type commitment :content (antecedent world-state (variable value)+) (positive/negative action who when)	(RedOp1) If Neighb1.BluePatrolLevel < .5, we'll attack Neighborhood1 in 4 turns.
Warn	If you (not) perform ActionX, then WorldState (not)= StateY If you (not) perform ActionX, actorY will (not) perform ActionY	:type warning :content ((antecedent action who when positive/negative) (resultant state positive/negative when) :type warning :content ((antecedent action who when positive/negative) (resultant action who when	(BlueMil) If you attack Neighborhood1 in 4 turns, Neighb1.BluePatrolLevel > .8 in 6 turns (BlueMil) If you attack Neighbhood1 in 4 turns, BlueMilitary will perform Detain&Arrest in 6 turns

		positive/negative)	
Request-action / command	Perform actionX	:type request :content (action when who)	(CivilGovt) Request (BlueMil) set BluePatrolLevel < .4
	Make WorldState (not)= StateX	:type request :content (world-state (variable value)+ when)	(CivilPop1) Request Neighborhood1.Hunger < .3
Request-info	Ask world-state info	:type request-info :content (world-state (variable value)+)	(CivilPop2) Request-info (CivilPop1) what is the BluePatrolLevel in Neighborhood1?
Request Permission	May I perform actionX?	:type request-permission :content (who when action)	(NGO1) Request-permission (BlueMil) to move into Neighborhood1
Respond-to-request	Grant/Deny	:type reply-permission :content (grant/deny referent)	(BlueMil) grant (NGO) (move into Neighborhood1)

This is obviously not a complete set to cover the full range of communicative acts in human speech. However, those listed in the table above are clearly well-grounded in data elements in the system for the agents to communicate about, and provide a rich enough set to enable interesting behavior.

There are many presumptions inherent in any communicative act. For instance, with a threat comes the presumption that the hearer believes the speaker's intent to fulfill the commitment entailed by the threat, and that the speaker has the capability to act on the commitment. It also presumes that the speaker believes the hearer would in fact feel threatened by the threat – that the promised retribution would have a negative impact on the hearer. Every such communicative act relies on these presumptions, which go hand-in-hand with the speaker's mental model of the hearer, and vice versa.

With communication comes the assessment that it is indeed useful and necessary to perform the communicative act and, on the other hand, that there are consequences to performing the act. This speaks to the idea of *utility* associated with the act, just as with any other action. In this model, we expect actions to use credits – it may be

that a communication is not so necessary that it is worth the credits required to perform the act.

For realism, and especially in terms of the cross-cultural effects of Info Ops, it seems critical to include the ability for the hearer to get a different message than that which was intended by the speaker. However, for a first cut, there should be no distortion in the message between sender and receiver.

Communication Example

In the case of one form of leaflets (the communicative medium), the user's intent (illocutionary act) may be to persuade the hearer to lay down arms. The form of the message (locutionary act) could be in the form of a request ("lay down your arms") combined with a promise from the user ("we will not prosecute you"). While the communicative act itself is fairly straightforward (i.e., no ambiguities), there may be multiple responses to the message on the part of the hearer. For example, because of distrust on the part of the hearer for the speaker, the hearer may not believe the speaker's promise and refuse to lay down arms. The hearer may understand the indirect speech act of a threat in the message – if they do not lay down arms, they will be engaged – and comply with the leaflet's message – hence, fulfilling the speaker's intent (perlocutionary act). Along these same lines, the effect of the utterance may be counter to the intent of the speaker – the message might enrage the hearer to fight more vigorously.

Communications by Actor Type

The different types of actors in the simulation have different kinds of communications that might be useful to them, and this may be based on perceived relationships between entities. For instance, the civil population may not have the authority to command the opposition force to perform an action. Table 4 below defines the set of communicative acts available to the different actors in the simulation.

Table 4 : Likely communications per actor type

Agent Type	Communicative Act
Population	• Tell adjacent neighborhood about a situation (inform)
Cleric	• Incite action in population • Inform population of a situation (including deception) • Inform another cleric of a situation
Regime Supporters	• Incite action in population • Command remaining militant groups • Inform population of a situation (including deception)
[user]	• Persuade hearer to act (threats, promises) • Inform the population of arriving humanitarian aid (inform)
Media	• Inform hearers of situations (with slant)
Tribes	• Incite action in population(Tom can expand this?)

Speech acts do not necessarily cover just typical communication modes like speech. For a single person, physical acts (such as gestures) can be included in a larger

taxonomy of communicative acts (due to Maybury, 1993). By extension, an armored battalion commander can use the movement of tanks in the battalion as communicative acts. For instance, moving tanks through Baghdad near the end of the second Gulf War was almost purely a communicative act – meant to show force, meant to show the implied imminent fall of the regime – all without firing a round. This communicative act is as much as speech act as a literal utterance, with all the many different effects on hearers. So, in a sense the physical act of moving tanks is merely the locutionary form of the illocutionary act of the speaker.

Deception is an intriguing aspect of communication that hasn't been investigated much in the literature, in terms of implementing *lying* agents.[53] In terms of the agent framework we have, lying is like any other action in that if the result of the action has a favorable outcome for the agent, it will perform that action. The difficult part, then, is to have the agent generate cogent deceitful content. A potential example might be if the speaker wants to invoke some action in another agent, and knows enough about how the agent would respond to certain (mis-)information, the speaker may utter the deception in order to "trick" the agent into performing the action. In the agent framework of Urban SUNRISE (borrowed from AGILE), the deception would have to be framed in terms of mis-representing a situation such that the hearer's goals become unmet and the hearer is drawn to performing the speaker-desired action.

Goals

An agent's goals help to define the agent's ideal world situation. In the case of the world model, an example might be to have the target city having electricity or to have an invading force driven out of the city. In the case of other agents, this might be to have other agents believe that if they turn in their weapons, they will not be engaged in battle.

Goals by themselves describe an ideal situation, but can also entail judgments about world situations. For instance, if the ideal situation receives the highest judgment, situations that are not ideal would score lower, and provide a basis for determining actions. As such, goals (and the judgments established by goals) form the foundation for agent decision-making.

world-model related goals: goals to change the situation reflected in the world model, such as wanting to cut off a communication link between two groups

communicative goals: a goal to invoke some behavior in another agent (may include simply desiring another agent to have a particular belief or know about some happening).

This expansion of goals to include more than world model variables presents a new challenge different from that of AGILE. In particular, these goals may have to do with the state of other agents in the system – e.g., the goal of wanting another agent to know some information requires that the agent have a model of that other agent and the model says the other agent doesn't know this information.

[53] A basic assumption in Speech Act Theory is that conversation is based on cooperation, exemplified by Grice's Maxims of communication. Deception breaks (most directly) Grice's Maxim of Quality, wherein there is a basic assumption of the truthfulness of the information presented in an utterance.

Beliefs

In general, beliefs describe the agent's worldview. This includes its understanding about how the world works (causality between related "variables"), how other agents work, declarative knowledge about the world (as seen from the agent's perspective), etc.

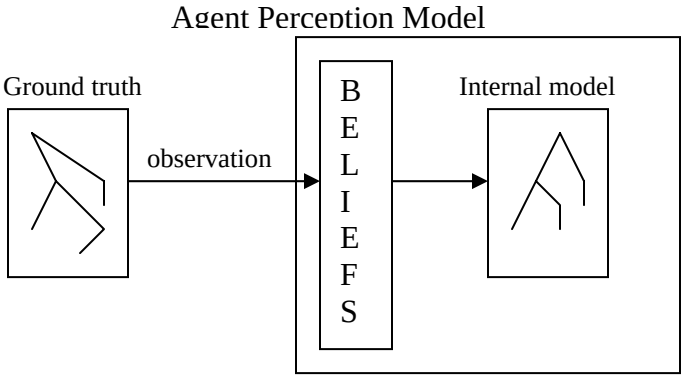
Beliefs about "facts" – describe the state of the world through the eyes of the agent. This implies a process of perception by which the agent observes some "fact" in the world and fits that fact into the agent's knowledge about the world, colored by the agent's beliefs.

Cause-and-effect beliefs describe how the world works: if I perform an action, what are all the consequences of that action? This also must include models of how other agents will react to the change. This is particularly important in describing the effects of communicative acts with other agents. Judgment beliefs (partly framed as goals) help the agent assign a value to the (current or imagined) state of the world.

In the AGILE model, all process-oriented beliefs are represented as rules and, as such, cannot be themselves reasoned about or easily modified. However, this form makes them immensely more efficient for Soar than if they were stored in an object structure that was later converted into a transformation on the fly.

Perception

Perception covers both the ability to perceive and the process of perceiving. That is, one can only perceive those events that are observable given particular capabilities on the part of the agent. Furthermore, perception often includes judgment: the observables are assigned some importance by the agent.



We can actually use the model given above for communication interpretation as a special case of general belief-modulated perception. The agent goes through a few distinct steps:

1) Perceive an event E
2) Determine all the meanings of E
3) Select the meaning of E, M, most consistent with agent's beliefs
4) Incorporate the event E and its meaning M into agent's belief structure

In this way, the agent's beliefs are used to guide the determination of the meaning of the perceived event. Additionally, beliefs guide the development of expectations based on the event and the judgments associated with the new expected states.

Suppose two agents see a US tank rolling through the streets of Baghdad. One agent has a belief structure that says the American presence will liberate the Iraqi people from tyranny. This agent sees the US tank as a sign of the US presence and so creates an expectation that liberation will follow. Another agent has a belief structure that sees American presence as occupation and a continuation of oppression. The tank symbolizes the beginnings of this occupation, and so the agent judges this event as having a negative effect in the future.

Agent Decision-making

Agent decision-making is the process by which an agent measures the world situation against its goals and decides whether or not an action is appropriate to bring the world more in line with its goals. With an understanding of how its actions would affect the world in various ways, the agent can imagine a new world situation if that action were to be performed, and measure the effectiveness of that new world given its goals. If the new world situation is judged to be better, that action is a potential candidate for execution. This process of perceiving the world, deciding what to do, and acting forms the basis for all agent decision-making in Urban SUNRISE.

Planning

We will use a version of the simple planning system analogous to that in AGILE:

Planning algorithm:

Given the current state St, and a set of actions A[a1, …, an].
Evaluate the current state, St, and assign it a value.
For each action ai, project the action from St to get imagined future world states,
St+s (short-term) and St+l (long-term).
Evaluate St+s and St+l and assign values for those new states.
Select the action aj with the highest combined short-term and long-term evaluations, ej.
Execute the best action.

Actions can be scheduled to happen in the future, but we will not generate elaborate plans for this first effort.

An expanded version of this that could be considered is to use recipes or plan templates that the agent can use as "pre-packaged plans", probably with instantiations necessary. These recipes have pre-conditions and post-conditions – pre- should match the current situation and post- should match the goal state (or intermediate subgoal state).

Spatial Reasoning

An aspect of Urban SUNRISE not present in AGILE is the ability for agents to do spatial reasoning. We will imagine the terrain of the city to be an adjacency graph of "nodes" representing areas that can be occupied by a physical presence, including some agents. With this representation of the city, the agents must have that representation (or some analog of it) in their knowledge base in order to reason about getting from place A to place B. Furthermore, there are constraints on how an

agent can move from A to B, such as the time it takes to move. Spatial reasoning may also necessarily include the ability to tell if an object (including the agent itself) is inside or outside a particular area on the map. Given this, a simple planning algorithm such as A* may be necessary to enable such movement ability.

Social Network Reasoning

Agent communication is, in some way, a plan to move a message from one point to another. This is true if there is a potentially long distance (in terms of intermediate nodes) between the sender and the intended recipient, whereby the sender must plan the most likely route and then choose just the first step – since the sender is (likely) only in control of only his or her own actions, not those of the agents in nodes along the path.

Communication is a special case of general action in which one agent desires to affect in some way another agent in the network. (Indeed, it may be that the agent only indirectly wants to affect that change, potentially for reasons of subterfuge or deception.) In this way, the agent must (again) plan the expected path of effects and response actions through the network, and select the action that will most likely create the desired change in the destination.

Generic Message Handling

Given the necessarily flexible and dynamic agent organization in Urban SUNRISE, the agents need a robust event handling system. In particular, an agent can receive a message at any time from another agent. The agent must be able to prioritize that message with respect to what it's currently doing (abort or continue), handle the message, and possibly return to what it was doing before the message arrived. The priority of the message over the agents what the agent is currently engaged in is based on the sender (and the agent's relationship to the sender) of the message and the urgency of the content.

Turn Completion

Like AGILE, Urban SUNRISE will be a turn-based game. This does not mean that the agents take turns acting; instead, the game progresses by alternating agent activity with world model activity. The SimServer maintains this synchronization. In order to move out of the agent phase, all of the agents must reach a quiescent point in their activity such that they can be considered "done" with their turn.

In Urban SUNRISE, we are dealing with turns on the order of a few hours to a day in duration. Given this short timeframe, it is important to keep agents from doing an infinite number of actions in a given turn. We will implement a credit-based system by which each action has associated with it a number of credits, and each agent is given a number of credits to spend each turn. Once the agent has spent all its credits, it cannot do more actions in that turn.

Furthermore, some actions will have constraints on them such that multiple such actions cannot happen twice in the same turn. For instance, one cannot move troops into one neighborhood, then into the next neighborhood in the same turn. Agents will have to know about these constraints so they can make sensible plans.

For the agent phase to come to a completion, all the agents must announce that their activity has ceased. However, an agent's activity is based partly on the number of credits it has left (if 0, its activity is done) and partly on the activity of other agents. In the latter case, one agent can send a message to another that has already

claimed it is done – and the second agent, if it has sufficient credits left, can renege on its declaration of turn completion and commit to another action. In this case, an agent's declaration of turn completion is considered *soft* – it is only meaningful when either 1) it is out of credits or 2) all the agents have proclaimed completion. When the second situation happens, the system moves out of the agent phase and into the world model update phase.

Cultural Variation

Culture, as a term, has many definitions. Here we take culture to mean the shared beliefs and problem solving methods within a group of people that share a common background. With this definition, we can relate culture to the decision-making processes described above. Cultural differences fall into three categories: behavior, values, and cognition. Behaviors represent the typical outwardly visible aspects of culture, such as language, custom, and dress. Values represent the common assignment of good/bad; right/wrong to situations and events. Cognition refers to the tendency to use different modes of perception, categorization, and problem solving. While behavioral differences are important in a thorough model of a society, we focus here on the value and cognition differences because of how they affect the types of decision-making we're interested in for course of action planning and evaluation.

Researchers in sociology and psychology have developed several taxonomies of value and cognition factors that affect cultural decision-making. Given the breadth in the types of characters we're attempting to portray in this setting, we anticipate a wide set of potential factors that may have effects on the decision-making of the actors.

Table 5: Examples of Dimensions of Cultural Variance (borrowed from Klein, 2001)

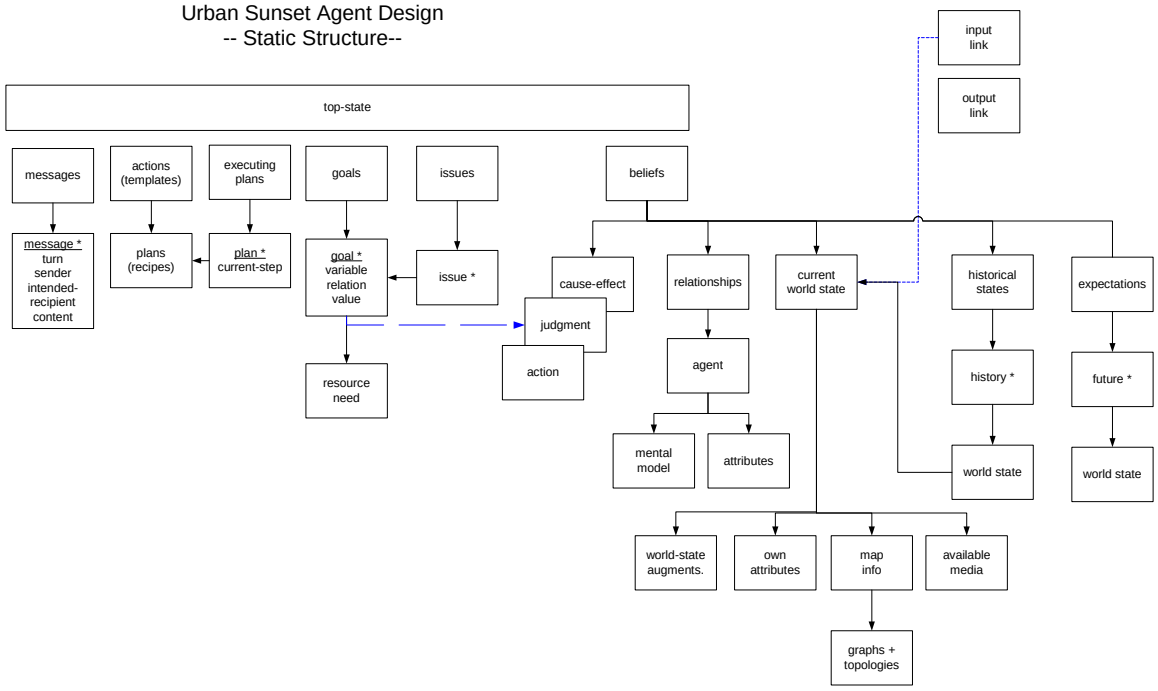
Power Distance – the extent to which the less powerful in a society expect and accept that power is distributed unequally.
Individualism-Collectivism – Individualism describes societies where each person is more or less on their own, where he or she takes into account mostly his or her perspective (and close family) in decision-making. Collectivism describes societies in which the there is a group loyalty and support network that provides a context for individual decision-making.
Uncertainty Avoidance – The extent to which people view uncertain situations as threatening, and the extent to which they make choices to avoid uncertainty. Part of this is the process of risk assessment – determining to what extent a given situation, and its component uncertainty, is risky.
Activity Orientation – The extent to which members of a society value pragmatic effects over social/relationship effects.
Dialectical Reasoning – The extent to which members of a society consider all likely actions and select the best versus looking for a holistic solution that favors compromise.
Counterfactual Thinking – The tendency to consider "possible futures" or "what-if scenarios" versus context-bound personal experience to generate plans.

The agent framework of Urban SUNRISE is based in the perceive-decide-act cycle described above, with goals and beliefs being the major elements of that cycle. How values and cognition affect the perceptual processes, the goals, and the beliefs of an agent is yet an open issue. Some exploration of this will be performed in this program.

Mental Models of Other Agents
In order for an agent to interact meaningfully with other agents, the agent must have some sense of what those agents are capable of and what their goals and beliefs might be. This allows the incorporation of others' possible decisions in a "what-if" generation of possible futures in planning.

Trust
Trust is a major factor in post-war reconstruction scenarios. Who trusts whom, and what relationships exist therein, is critical to understanding how to engender cooperation among actors, and how to ferret out support of insurgent factions. We will consider trust as a factor that helps define relationships between agents in the simulation. See the paper "A Computational Model of Trust in SASO" for more details along these lines.

Appendix A : Static Data Structures of an Agent



Appendix B : Example Agents

Table 6 : Example Agents, attributes, goals, and actions

Agent	Attributes	Goals	Actions
Local Civil Authority (mayor, interim gov't)	Authority [0 – 1] FoodAidResources [units] MedicineResources [units] MonetaryResources [units]	Authority > .7 Security > .7	Call for Calm Call for Demonstration Subsidize Warn Censor License Shut Down Organization(?)
NGO1	FoodAidResources [units]	CivilPop1.hunger < .3 CivilPop2.hunger < .3 CivilPop3.hunger < .3	Move DistributeResource
NGO2	MedicineResources [units]	CivilPop1.disease < .3 CivilPop2.disease < .3 CivilPop3.disease < .3	Move DistributeResource
Civil Population1	Hunger Disease Liberty	Hunger < .2 Disease < .2 Liberty > .7 Keep-civilPop2-notified	Assemble Demonstrate Protest Riot Sabotage/Destroy [stay home]
Civil Population2	Hunger Disease Liberty	Hunger < .2 Disease < .2 Liberty > .7 Keep-civilPop1-notified	Assemble Demonstrate Protest Riot Sabotage/Destroy [stay home]
Civil Population3	Hunger Disease	Hunger < .2 Disease < .2 Regime.Authority > .7	Assemble Demonstrate Protest Riot Sabotage/Destroy [stay home]
Cleric1	Authority	Authority > .5 Blue.Authority < .1 Regime.Authority < .1	Call for Demonstrations
Cleric2	Authority	Regime.Authority < .2	Call for Calm
Red Opposition1	Authority	Authority > .7 Blue.Authority < .1	Move GuerillaAttack
Red Opposition2	Authority	Authority > .7 Blue.Authority < .1	Move GuerillaAttack
Regime	Authority	Authority > .9	Order Attack Order Riots